Gas Journal

VOL. 301 112th YEAR LONDON, JANUARY 6, 1960 No. 5027 PRICE 1/6

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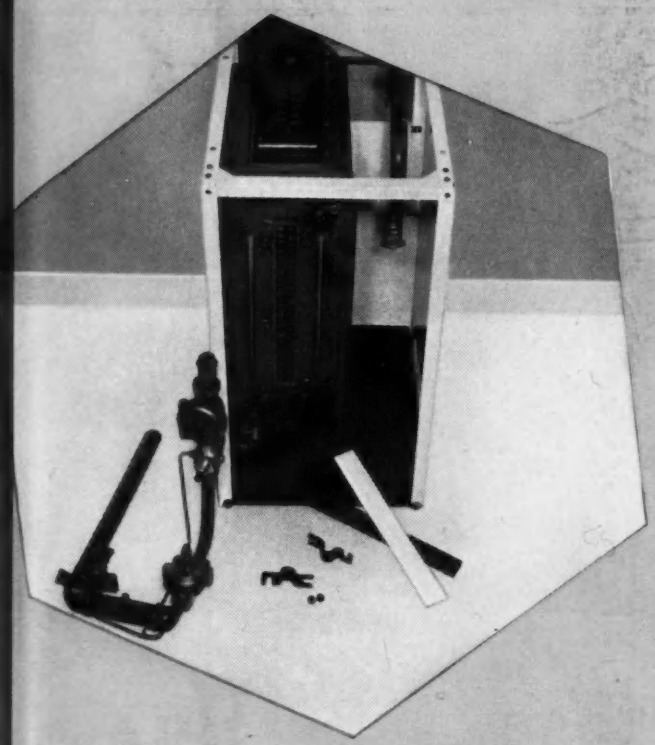

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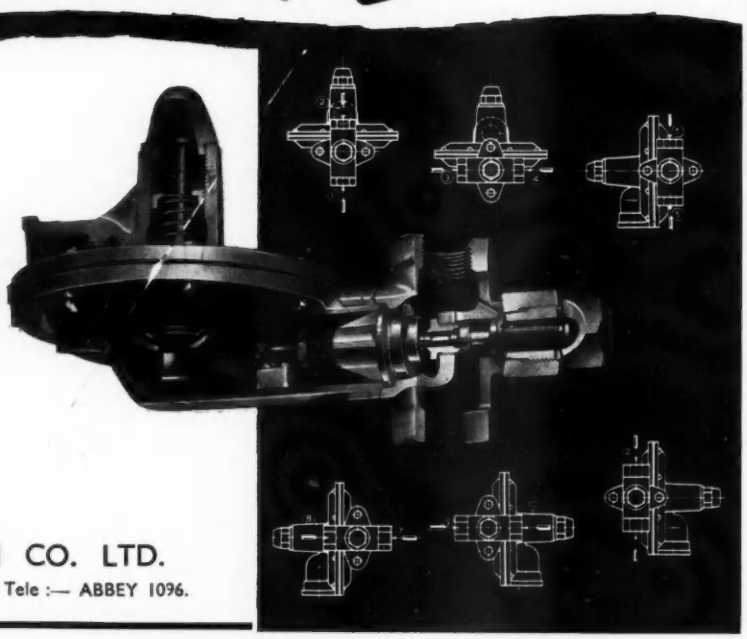

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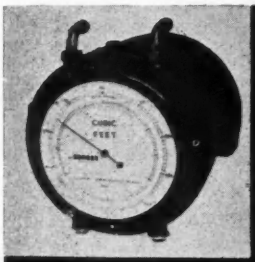

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Gas Journal

VOLUME 301 • NUMBER 5027 • 112TH YEAR

WEDNESDAY, JANUARY 6, 1960

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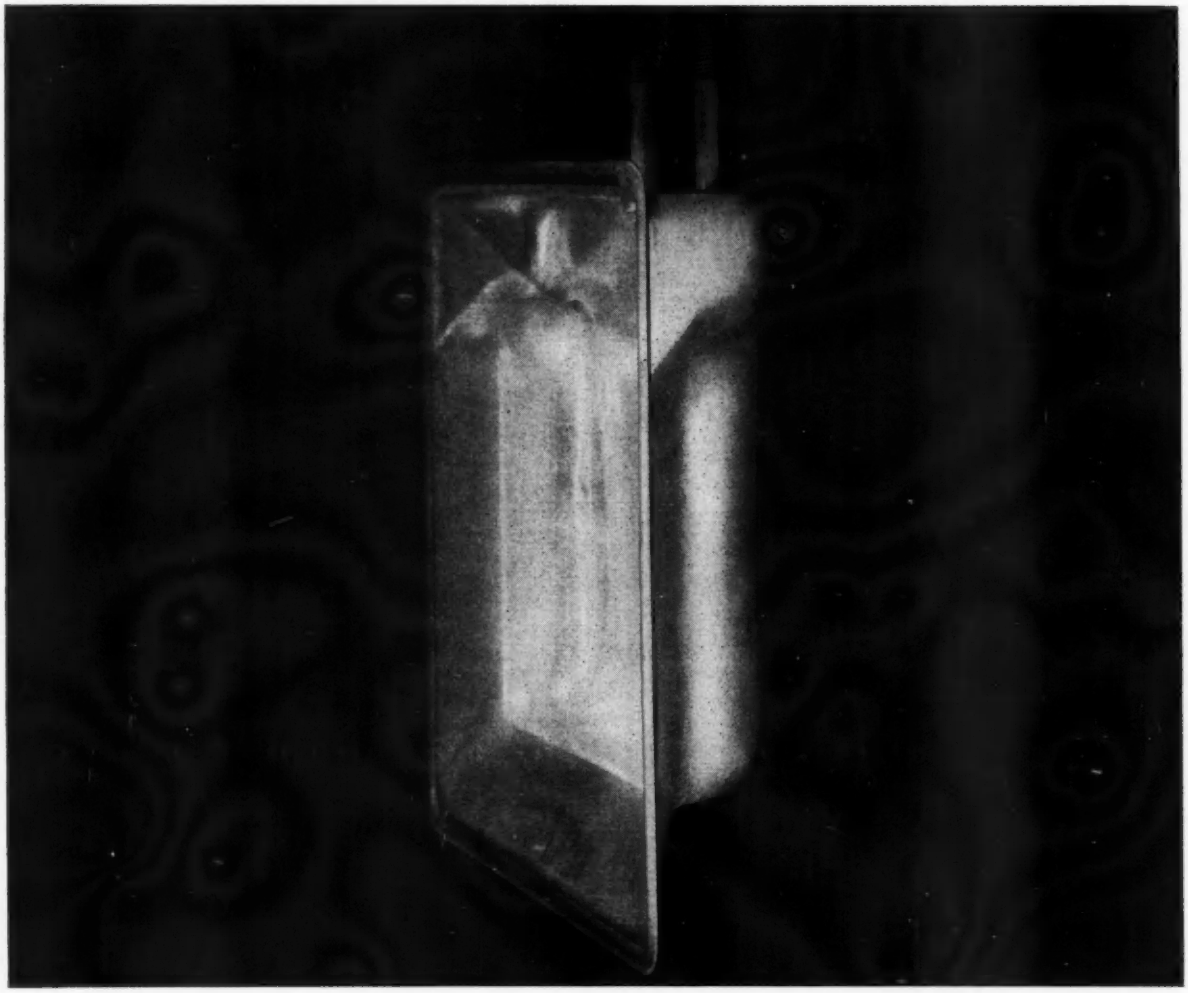
Publishers' Notice, See Page 385, November 25, 1959



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Progress in Liquid Purification

WE are publishing this week the first part of an article by Mr. A. R. Myhill on 'Removing Hydrogen Sulphide by Liquid Purification,' and we feel that this particular survey of the processes now being exploited, is of particular interest at the present time.

Iron oxide in boxes or towers for gas purification is performing its function quite satisfactorily, but there are a number of factors with which the gas engineer is compelled to reckon. Of these, the two most important are the supply of labour for changing the oxide and the saleability of the spent oxide as a source of sulphur.

Since the end of the second world war, labour has been increasingly disinclined to undertake such arduous and unpleasant jobs as digging out oxide from purifier boxes, but since this method of gas purification has proved itself second to none when the Statutory Regulations governing the purity of town gas must be satisfied, great ingenuity has been used to design means of mechanical handling. In the most modern systems, the development of mechanisation is so far advanced that very large plant, satisfactorily treating as much as as 30 mill. cu.ft. per day, may be run by as few as four men who are little more than machine drivers or attendants.

Why then should there be this great interest in purification by other processes employing different media and other reagents? There are, we think, several reasons for this, the two most important of which are the saleability of the product, sulphur, and the ease of control of the process when liquids are conveyed by pumping compared to working with solid media.

From the solid spent oxide, sulphuric acid can be obtained by burning the oxide under special conditions to form sulphur dioxide and a sulphur-free solid residue. The sulphur dioxide can be oxidised to the trioxide and so become the basis of sulphuric acid manufacture by the 'chamber' process; but this is a low grade acid. Care must also be taken when burning the oxide to prevent it becoming unfit for further use in gas purification, and thus difficult to dispose of.

Added to this, sources of sulphur are becoming available from which a purer product is more easily obtainable and a higher quality sulphuric acid may be manufactured by the 'contact' process.

The new gas purification processes being exploited in Great Britain at the present moment have mostly come from abroad and have had to be modified to make certain that the standards of purification do indeed comply with the Statutory Regulations, which are often far more severe than any similar regulation abroad.

Such a process as the Gastechnik process from Germany is a good example of the sulphur being extracted by solvents from a solid spent purifying material and being sold as such in a light state of purity, but we feel that the whole trend of contemporary thinking is away from such systems. It is far more likely to be towards gas purification by media which make possible the development by means open to chemical engineering exploitation. This point is also confirmed when the present-day tendencies in gas manufacture are reviewed.

The use of high pressures in gas-making processes will naturally make necessary certain modifications to the well established purification methods in any case. Mr. Myhill points out that even the increased solubility of hydrogen sulphide in water under increased pressure is a most useful property and will make possible a great reduction in hydrogen sulphide content by spraying the gas by water alone.

As is well known, the idea of the liquid purification of town gas is by no means new. Perhaps the best known and the most successful system in Britain is the 'Manchester' process which was originally developed in America and modified by gas engineers working round Manchester to make it suitable for gas purification according to British standards. Although it was successfully modified by increasing the number of absorption vessels, and gas was purified to the standards demanded, difficulties arose over the corrosion of the vessels themselves. This latter difficulty seems to have been largely overcome, and two recent plants at Cardiff and Bristol are giving satisfactory results.

Another system, the Perox process, is well known in Germany and has successfully purified coke oven gas, but the latest type of liquid purification plant to be built in Britain is the W-D-Koppers vacuum carbonate plant

lately commissioned at Beckton. In this process crude gas is washed with a carbonate solution from which the hydrogen sulphide is extracted under reduced pressure and finally converted to a high quality sulphuric acid in a modified 'contact' acid plant.

The chief disadvantage of this process, it seems to us, is that the absorption in the carbonate solution is reversible, and it is not therefore possible to extract all the hydrogen sulphide completely from the gas. In practice about 90% is absorbed and the remaining 10% is taken out by oxide purifiers. This in itself seems a great drawback, but we feel that, although an oxide plant acting as a usually large catchbox is necessary, the plant at Beckton does at least partially satisfy the conditions we referred to earlier; manpower has been greatly reduced, the navvy type of labour has been avoided as far as possible and the product to be disposed of is of high enough quality to command a good price.

We look upon this development at least as a great step forward and a pointer towards the future, but we were extremely interested in Mr. Myhill's reference to work which has been carried out lately on the use of certain organic dyestuffs which form leucobases by reduction. They are easily re-oxidised to the original dyestuff and these properties make them a suitable means of oxidising hydrogen sulphide to a pure form of sulphur, after which the original reagent is easily recoverable. This particular mechanism has been investigated by our own gas industry and has been tested in a small pilot plant.

In our opinion the industry will demand the perfection of some form of liquid purification for town gas, since it must be admitted that, although successful, purification by solid iron oxide is largely empirical.

Since the war great strides have been made in understanding the mechanism by which hydrogen sulphide and iron oxide react, and much has been done in studying the conditions inside a purifier box. The intimacy of contact between large volumes of gas and a large mass of solid reagent is a difficult thing to control, and clearly even the most up-to-date, mechanically-aided oxide purifier systems can really only scratch the surface of the problems involved.

We see in the partnership between the chemical engineer and the station engineer, both determined to solve the present difficulties inherent in liquid purification systems, a means by which the extraction of sulphur from town gas may be put on a sound scientific basis.

Pioneer in Coal Tar Distillation

THE 150th anniversary of birth of Read Holliday of Huddersfield which fell last month brings to mind the founding by this Yorkshire industrialist of a firm which just 100 years ago produced aniline and other intermediates. Read Holliday & Company were to rival Levinsteins in manufacturing intermediates and dyestuffs, and along with Roberts, Dale & Company of Manchester and Simpson, Maule & Nicholson enabled Perkin's coal tar dyestuff industry to develop, to equal the French developments of Rénard Frères and Monnet and Drury. And it was on a piece of land on which gasworks tar had been dumped that Read Holliday took on his commercial venture with such success.

Holliday came on the scene with no chemical training, no schooling in chemistry under the eminent Hofmann, who had trained young Perkin, Nicholson and others who made history in the coal tar dyestuff industry. The son of a Yorkshire wool-spinner, he had moved from Bradford when only 21 to his Huddersfield site, there to begin the production in a small works of ammonia from gasworks liquor. By the age of 30 Read Holliday had moved to the Turnbridge site in the Huddersfield area, one which was to become the centre of a Yorkshire industry. Dumas, Runge, Hofmann and others had studied on a laboratory scale the various distillates to be won from coal-tar, providing a basis of knowledge when new raw materials or intermediates for new dyes were needed. A far-sighted Prince Consort had caused the maestro A. W. Hofmann to be permitted to come to the Royal College of Chemistry, then in Oxford Street, to inspire not only Perkin and Nicholson, but Peter Griess, discoverer of azo-dyes, and Medlock. Yet while Hofmann himself and his pupils were concerned with production of aniline and other coal-tar bases en route to new dyes, it needed practical men like Holliday to manufacture those essential distillates like benzole and toluole for nitrating and converting to such bases.

At Huddersfield the first efforts to find applications for 'worthless' tar dumped by the local gasworks were less promising than after Perkin had created a far more striking outlet for tar products. While H. P. Burt, who founded the firm of Burt, Boulton & Haywood, built a tar distillery to provide creosote for preserving his timber, Holliday began compounding tar with coal ashes as a briquette fuel for his works. He introduced a naphtha lamp for lighting and for use on railways before Young's kerosene lamp and later gas lighting brought applications to an end. Yet just as James Young turned to oil distillation for various distillates, so did Read Holliday see in coal-tar distillation a rich source of volatile products apart from creosote as preserving-agent. He took on his staff Charles Mansfield, who carried out many distillations and described the principle of dephlegmation for separating the various hydrocarbon fractions, while also pointing out that stills similar to those used in rectifying alcohol might be adopted for preparing benzole and other fractions. Mansfield died from severe burning, a martyr to tar distillation when a still boiled over and the contents caught fire.

Read Holliday extended his tar distillation industry to other Yorkshire towns and also took on the Bow works. this after he had studied various aspects of the French industry (which was in advance of the British industry early in the 1850's). He brought back from the Paris gasworks one of Pelonge's assistants to improve his benzole production. It was a period when coal-tar benzole prices were fluctuating greatly; for while five shillings a gallon was charged for benzole at the time

when Perkin discovered his mauve or mauveine, the price rocketed to 18 shillings a gallon before prices became more stabilised. Holliday represented the Yorkshire industry with dyes and intermediates as the answer to rivals in Lancashire, even though he had not the expert organic chemists in the Manchester 'German colony' who had come from Hofmann's training.

Roberts, Dale & Company were contemporaries and rivals to Read Holliday since both firms began in 1860 to manufacture magenta to add to their aniline, toluidine and other products.

Since Nicholson had some years before introduced arsenic acid for oxidising crude aniline, while Medlock had stipulated dry arsenic acid in his patent, there came the intense battle of magenta in the courts, a bitter litigation which cost Read Holliday £5,000 since he too was using the arsenic acid process. Later he was able to manufacture the new dyestuff, and followed this with patents for improved blues, violets, reds and greens, with alkylated rosanilines, azo-scarlet and Bismarck brown added to his score. When Read Holliday died 70 years ago he left a flourishing chemical firm, a noteworthy creation from the hands of a pioneer who had faith in 'worthless' gasworks tar.

Commentary on the News

Brighter Prospects for Paint Makers

NATIONALISATION of the gas industry has been very far reaching in its effect on many things, the paint trade among them. When the bulk purchase of paints by the area boards was studied, following a decision that advantages would be gained by bulk purchasing, a panel working with the National Gas Council produced 26 composition specifications which were named G.I. Specifications. These were distributed to the area boards with the recommendation that the paints concerned should constitute the main steelwork protective coatings for future maintenance painting.

Before nationalisation, the supply of such protective paints for steelwork was, broadly speaking, in the hands of perhaps a dozen manufacturers, well versed in the needs of the gas and coking industries, who frequently 'tailor-made' a paint to suit a special set of conditions, gas engineers placing reliance in the technical ability of these firms to supply them with suitable materials.

Following the issue of these G.I. Specifications, however, the opportunity to supply was thrown open to the whole of the British paint industry—literally hundreds of firms competing one with the other—and based on the assumption by the purchaser that all paints made to these specifications should be equal between one manufacturer and another, the lowest quotation is usually accepted.

While this may be of advantage to the gas industry, it must be remembered that the manufacture of paint to a composition specification does not guarantee that the finished product will prove satisfactory in every case. The simile that the same cake recipe handed to two housewives does not guarantee that both will provide edible cakes, has occasionally been used in this connection, and obviously there is far more in making paint out of the correct ingredients than by just mixing them together in a bucket and stirring them with a stick.

A certain amount of paint testing is carried out by several boards. This is not only a costly process, but is very specialised work and difficult to carry out by staff not adequately trained for such work. The position, therefore, with regard to ordinary 'run of the mill' gasworks maintenance paints is not very bright in the paint industry. Several boards have, however, become increasingly interested in new developments in metal preparation and coating techniques, and this has certainly given manufacturers an opportunity of reverting to 'tailoring' painting systems to suit special conditions. This is rather gratifying, because we suspect that manufacturers were beginning to feel that this adoption of G.I. Specifications was stultifying research and development in paints so far as the gas industry was concerned.

An instance of this renewed interest is the exceptionally highly chemical resistant epoxy resin finishes which are being closely investigated and used to considerable advantage by several of the area boards. The return to a brighter future for the paint industry may lie in these specialised finishes.

Approval Seal for Oil Heaters

WE have on various occasions commented on the unfair amount of publicity given to gas as a possible source of danger in the home, and a week or so ago we expressed the wish that the gas industry publicised its admirable appliance testing methods more forcibly. We also announced the electricity industry's plans to give electric appliances a seal of approval. Now comes news of a somewhat similar system being adopted by makers of oil heaters.

According to a report in *The Times*, the British Safety Council called a meeting of 46 manufacturers of 120 types of oil heaters. The national director of the council, Mr. Leonard D. Hodge, told a Press conference: 'We have in the past refused to approve any oil heaters. We were not satisfied with the performance of heaters and the majority of standards.' The council now felt that a constructive step should be taken to help the public, though they still considered paraffin an extremely hazardous fuel and one about which not enough was known.

Of the recommendations discussed, Mr. Hodge said that the majority of manufacturers had accepted them either whole-heartedly or in principle. Within a month the public should be able to walk into a shop and choose a heater bearing the council's seal of approval. This would mean that it had passed tests in an independent laboratory and conformed to their standards. Asked how they could be sure that manufacturers would conform to the council's proposed standards, Mr. S. J. Winfield, of the Oil Appliances Manufacturers' Association, replied: 'I don't think you will find that traders will handle a heater that hasn't the seal.'

Among the recommendations was one that 'fuel bowls should be so constructed as to be unspillable,' and another that a cut-off valve should stop the fuel flow when the heater was lifted. More stringent specifications were also recommended with regard to draughts. Up to 90 ft. a minute, a draught should have no effect on the flame. With higher winds, the test would be deemed passed if after ten minutes a piece of flannelette on which the heater was standing had not smouldered or ignited.

REMOVING HYDROGEN SULPHIDE BY LIQUID PURIFICATION

Part—1

By A. R. Myhill,

F.R.I.C., M.Inst.Gas E., M.Inst.F.

IT has long been recognised that the conventional method of removing hydrogen sulphide from crude gas, by passing the latter through a static bed of iron oxide in powder or granulated form, although a firmly established process in gasworks practice, is not without serious disadvantages. On this account, purification by other means has, for many years, been the subject of much discussion and experimentation.

The requirements of Statutory Regulations regarding 'complete' absence of H_2S in town gas have, up to the present, necessitated the erection of plant of cumbersome dimensions, and the employment of a disproportionate amount of labour of a type often difficult to obtain, for emptying and re-filling box and tower purifiers.

Much criticism has been directed against a law which, while requiring complete absence of H_2S, takes no cognisance of the remaining sulphur compounds still left in the gas, particularly since the cost of removing the H_2S is closely related to the abstraction of the last traces; i.e., very small quantities which, expressed as sulphur, represent, in many cases, an amount which is much larger than that of the organic sulphur still remaining.

Some protagonists have advocated considerable latitude in respect of allowable amounts of H_2S, provided the total sulphur content is kept below a prescribed maximum.

Worthy of target aim

The difficulties and costs of adapting existing purifying systems to this end have, in many cases, militated against such a policy, and the regulations still exist in their original stringent form. There is, in fact, no doubt that the importance of complete removal of sulphur in all forms is sufficiently urgent as to be worthy of target aim, and, indeed, this standard seems likely to be realised in the comparatively near future.

An important aspect of purification from H_2S is the revenue obtainable from recovered sulphur, and in oxide purification as normally carried out, this is not as remunerative as might be expected on account of competition with other sources of sulphur which yield the product in much purer form.

Improvements on conventional purification practice have been suggested, and, to some extent implemented along two lines of approach:

1. Modifications in methods of handling solid (oxide of iron) purifying material to avoid the labour consequent on emptying and re-filling purifiers. Improvements along these lines have been effected in the dynamic systems, such as Gastechnik, in which pelleted oxide is allowed to move by gravity in contact with the gas, and is discharged intermittently in a fouled condition into receiving hoppers. Revivification can be carried out *in situ*, and high grade sulphur can be recovered by the use of a suitable solvent.

2. Liquid purification methods employing vessels much smaller than are necessary for static oxide purification and which, therefore, are very economical in ground space.

These methods can generally be operated to incorporate sulphur recovery. It is with these latter types of plant and processes that the present article is concerned.

By using a liquid purifying agent—which may be either a solution or a suspension of the active material—it is possible to obtain the advantages of the close control of operating conditions which is associated with the use of washers and scrubbers. In many cases, automatic devices can be installed to this end.

While 'complete' removal of H_2S is an essential characteristic of conventional oxide purification, liquid processes may be designed for either partial or complete removal, and the circumstances and objectives of each case will determine the type of plant to be used, and its method of operation. Where the gas is to be distributed for public use, it is, of course, necessary to carry purification to the legal limit, so that, when using a process of the type which leaves a small, but finite partial pressure of H_2S in the washing medium, it will be necessary to follow up by further treatment to remove the last traces. This is generally carried out in a small auxiliary purifier containing iron oxide. Cases may arise, however, where it is not necessary to remove the H_2S completely, as, for example, in coke-oven practice where the gas is used for firing the ovens, or/and where gas is sold to a gas board which undertakes its final purification.

Schemes of purification, in which combinations of wet and dry methods are employed, can be grouped into two categories; those in which oxide purification follows liquid washing, and those in which the liquid process follows the oxide plant.

Would reduce costs

An example of the latter class is a case where it is desired to purify gas containing only small quantities of H_2S,—say, 10 to 12 ppm. This may sometimes arise through contamination of town gas in a holder, due to bacterial action on sulphates dissolved in the water, whereby sulphides are produced. It can also occur in an active carbon benzole plant by mercaptan hydrolysis, or in the reforming of petroleum gases containing sulphur. It has also been suggested that in some cases it might be profitable to operate ordinary oxide boxes or towers at much higher gas throughputs than is customary, involving a small slip of H_2S which could then be cleaned up in a suitable washing plant. It is claimed that this would probably reduce overall purification costs very considerably.

Liquid purification technique is particularly applicable to

the newer methods of gas manufacture which operate at high pressures. In these processes, the bulk of the H_2S can be removed by simple water-washing under the prevailing high pressure in the plant; final removal being effected by means of iron oxide. Alternatively, complete removal to legal requirements may be practicable by employing irreversible absorption processes without the necessity of an oxide catch box.

The following processes are now in use for liquid purification; some are operating successfully on a large scale in Britain, on the Continent, and in America, and others are, as yet, only in the pilot-plant stage of development: (a) The Manchester process, (b) the Perox system, (c) the W-D-Koppers vacuum carbonate system, (d) washing with compounds of zinc, (e) processes operating under high pressure, and (f) the removal of H_2S and the recovery of sulphur by using an organic oxygen carrier.

The Manchester process[1, 2].—The system now operated in this country under the name of the ' Manchester ' process is an adaptation of the Fernax process which was in use in America nearly 40 years ago. In its original form, it was not possible to obtain removal of H_2S to the extent legally imposed for town gas in Great Britain. This was mainly due to the employment of a single scrubber for a washing process in which a small, but definite vapour pressure always exists in the gas in contact with the washing medium. The essential difference between the Manchester process and the original Fernax system lies in the application of multi-stage washing, using fresh liquor for each washing stage. Experience has shown that six washing stages in series will ensure purification to well below statutory requirements.

Basic principles

Details of plant operation and composition of the washing medium vary somewhat with different installations, but the basic principles remain the same. The crude gas is washed with an alkaline solution containing a fine suspension of hydrated ferric oxide. The fresh solution may be prepared by mixing solutions of copperas (ferrous sulphate) with alkali, which may be either sodium carbonate or ammonia. After use in the plant, the bulk of the wash liquor is regenerated and re-used, together with the necessary make-up of fresh solution. Hydrogen sulphide in the gas reacts with the alkali to form soluble alkali sulphides, which are capable of reacting with the iron oxide to form ferric sulphide with regeneration of alkali. Although the absorption of H_2S by the alkali is rapid, the reaction of the alkali sulphides with the iron oxide is comparatively slow, and only takes place to a small extent in the scrubber itself, so that it is necessary to provide external reaction vessels in which sufficient time is allowed for the complete conversion of alkali sulphides into ferric sulphide. After this has taken place, the ferric sulphide is regenerated as ferric oxide by exposure to a stream of air in the oxidisers. In the course of this reaction, free sulphur is formed and this may be recovered as a saleable by-product.

The reactions are as follows:—

1. *Formation of hydrated ferric oxide in suspension:*
   (a) $Na_2CO_3 + FeSO_4 = Na_2SO_4 + FeCO_3$.
   (b) $FeCO_3 + H_2O = Fe(OH)_2 + CO_2$.
   (c) $4\ Fe(OH)_2 + O_2 = 2\ Fe_2O_3 + 4\ H_2O$.
2. *Absorption of hydrogen sulphide from gas:*
   $Na_2CO_3 + H_2S = NaHS + NaHCO_3$.
3. *' Delay ' reaction to form ferric sulphide:*
   $3\ NaHS + 3\ NaHCO_3 + Fe_2O_3 = Fe_2S_3 + 3\ Na_2CO_3 + 3\ H_2O$.
4. *Oxidation of ferric sulphide by air:*
   $2\ Fe_2S_3 + 3\ O_2 = 2\ Fe_2O_3 + 6\ S$.

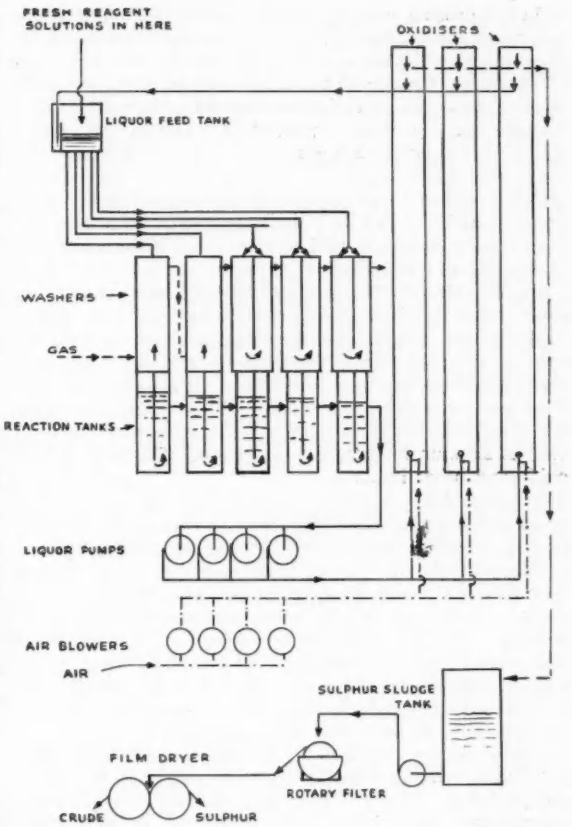


Fig. 1. Flow diagram of the ' Manchester ' process.

The practical operation of the process will be understood by reference to Fig. 1.

In this plant are five absorption towers, each mounted on a vertical cylindrical reaction tank. The crude gas enters at the bottom of the first tower in contra-flow to the absorption reagent, and then passes upwards through the second, and so on through the whole series. The last three towers are each divided into two passes by vertical division plates, the gas passing downwards through the first sections of these in the same direction as the reagent, and upwards, in contra-flow, through the second sections as shown. The absorption reagent consists mainly of oxidised liquor mixed with a small quantity of fresh make-up, and flows by gravity to all towers in parallel. Tower fillings are of flat steel slats in the first two effects, and boards on edge in the later effects. Heavy irrigations are used, which, in a unit purifying 6 mill. cu.ft. of gas per day would be of the order of 1,000 gal. per sq.ft. per hour. Liquor leaving the washers runs directly into the reaction tanks where conversion from alkali sulphide to fixed ferric sulphide takes place. The liquid is then pumped up the oxidising columns where it is blown with air through a venturi injection system as fine bubbles. The upward travel of air bubbles, free sulphur and iron oxide results in the production of a sludge or froth at the top of the oxidisers. Sulphur and ferric oxide are floated off and the liquid fed back to the liquor feed tank. In a 6 mill. cu.ft. per day unit, circulation through the washers would be 200,000 to 300,000 gal. per hour.

The sulphur froth is broken down by defrothers[1] and the sludge flows to a tank from which it is pumped to rotary vacuum filters for the recovery of crude sulphur.

In this process, difficulty is sometimes experienced in disposing of the crude sulphur produced, particularly in the face of present competition by brimstone at low prices.

The material normally contains a considerable proportion of iron oxide and other impurities, and is often difficult to remove from the sludge by filtration. The particle size of the sulphur is small—2 to 4 microns in the sludge—and this may give rise to dust in dry weather. A considerable improvement in filtration rate can be achieved by first boiling the sulphur to effect coagulation. This technique has been used successfully at Liverpool by Townsend[2] and is also in use at Cardiff[1].

In the latter plant, the sludge, containing about 6% of sulphur and 1.5% of ferric oxide, is pumped to a steam-heated sludge boiler and, after coagulation of the very fine sulphur particles, it is gravity-fed to the filter bath of a Davy Paxman vacuum drum filter, fitted with stainless steel gauze and nylon filter cloth. The sulphur cake from the revolving filter drum contains approximately 40% to 45% of sulphur, 35% to 40% water, and 15% to 20% iron oxide and other impurities.

Townsend[2] has described a plant working at Liverpool under closely controlled conditions in which continuous production of sulphur of 90% to 95% purity is possible.

The problem of upgrading the quality of the crude sulphur is still a serious drawback to the economics of the process, and a considerable amount of investigation is still going on. Powdrill[1] has given detailed figures of purification costs of the 'Manchester' process at Cardiff. These costs are closely related to the load on the plant. At full load, total purification costs, excluding capital and maintenance charges, average about 0.4d. per therm. The cost of the Cardiff plant was £54,000 as compared with £93,000 for an installation of oxide boxes of the same capacity, the capital charges being .07d. and .12d. per therm respectively. Maintenance costs were .05d. per therm, which is rather higher than those for conventional oxide purification. Ground space is considerably less and the labour requirements of one man per shift obviates the necessity of having on call a relatively large body of men available for intermittent work, as is the case with conventional static oxide purification. Such work is often very arduous and uncongenial, and difficulty may be experienced in obtaining sufficient labour strength for the job.

The Perox system.—With certain processes of liquid purification designed to recover sulphur, it is necessary first to isolate the H_2S and to treat this in a separate unit of plant in which elementary sulphur is recovered, as, for example, by incomplete combustion in a Claus kiln. In other cases, where sulphur is not needed in the elementary form, direct total combustion of H_2S to SO_2 and SO_3 can be employed. These processes are sometimes used at coke

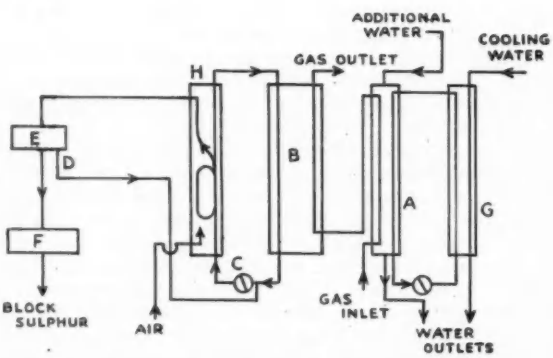
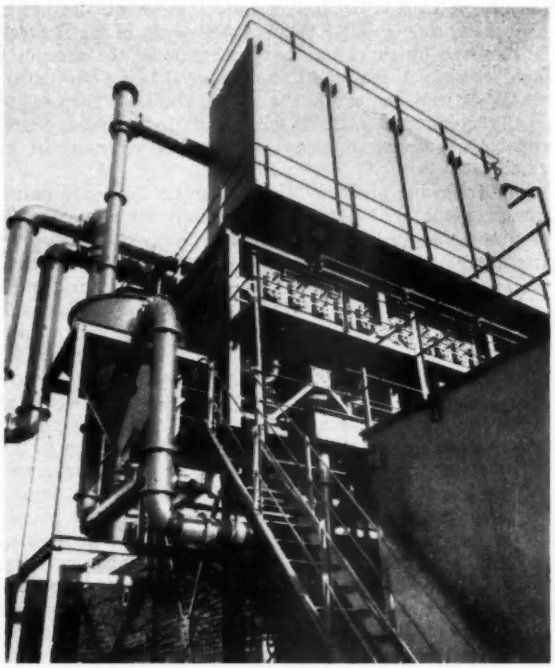


Fig. 2. Flow diagram of the Perox purification process.



A 'Manchester' process plant at Birchenwood.

oven works and other installations where purification and acid manufacture are carried out at the same station. In most gasworks, however, it is customary to sell sulphur in some form to outside manufacturers of acid.

The Perox process, now in operation on a large scale in Germany, seeks to avoid the necessity of isolating H_2S by using a liquid purification plant in which the oxidising reaction of H_2S to free sulphur takes place in solution. This is achieved by using a special washing liquid containing a catalyst. The principles of operation will be understood by reference to the flow diagram given in Fig. 2.

The plant is positioned at the outlet of the works exhausters or outlet of the detarrer. Crude gas is well cooled to approximately atmospheric temperatures or lower, by direct contact with cold water in the cooler and final condenser (A). The water absorbs part of the ammonia, and carries away any condensed tar and naphthalene remaining in the gas. The cooled gas, now containing a considerable amount of ammonia and most of the original H_2S, passes to the Perox scrubber where it is sprayed with a special solution containing about .3 g. per litre—20 grains per gal.—of a suitable catalyst. Certain polyphenols notably hydroquinone, are used as catalysts and these substances produce oxidation of H_2S in solution without impairing the washing properties of the liquid.

In the Perox scrubber (B), the acid constituents, H_2S, CO_2 and HCN, are removed as ammonium salts by the ammonia contained in the gas. The washing medium containing the catalyst is circulated through the scrubber and the oxidiser by means of the pump (C), which receives the solution from the filter outlet (D), together with a certain amount of 'make-up' to replenish lost material. The solution first passes upwards through the oxidiser towers, arranged in parallel (H), and thence downwards through the Perox scrubber and back to the pump for re-circulation. Compressed air for oxidation of the H_2S absorbed by the

Continued on p. 30.

25th AUTUMN RESEARCH MEETING

Carbon monoxide removal from fuel gases

By

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CARBON monoxide can be removed from town gas by catalytic reaction with hydrogen to give hydrocarbons, by absorption in cuprous salt solutions or by reaction with steam on a catalyst to give carbon dioxide and hydrogen. The last method, known as the water gas shift reaction, is the most promising and has been used to treat the gas produced at Hameln and Nordhausen before the second world war, and at Basle since 1958. The gas treated at these places was mainly coal gas, whereas in Great Britain more interest is attached to the treatment of carburetted water gas.

Under these circumstances, the main problem associated with the water gas shift process is the fouling of the catalyst, which is attributed to the interaction of conjugated diolefins, nitric oxide and oxygen on the surface of the catalyst. Fouling can be minimised by removal of these constituents by a pretreatment catalyst.

If the carbon dioxide formed in the water gas shift reaction is removed from the treated gas in order to maintain its calorific value, the gravity of the product will be considerably below that of the original gas. For this reason, and because of the high cost of carbon dioxide removal, close attention has been paid to the extent to which this is desirable under a variety of conditions. The extent to which carbon dioxide need be removed can be reduced by using light distillate as a feedstock and by the admixture of rich gas to increase the calorific value. For the cases considered, the range of removal extends from 75% down to 16%. For partial removal, the most promising processes are those based on ammonia or activated potasium carbonate as the absorbent.

Two reactions

In the shift process, steam is added to the water gas and the mixture passed through a heat exchanger to a catalyst in the temperature range 300° to 550°C. The following two reactions occur:

$$CO + H_2O \rightleftharpoons CO_2 + H_2$$

$$2H_2 + O_2 \longrightarrow 2H_2O$$

If the mixture contains 100 moles steam per 100 moles dry carburetted water gas, then the adiabatic temperature rise due to the reaction of .6 moles of oxygen is 39°C., and that due to the conversion of each mole of carbon monoxide is 5°C. Thus, if 25 moles of carbon monoxide are converted, the total temperature rise is 164°C.

Complete removal of carbon monoxide is not possible, the minimum residual carbon monoxide being controlled by the reversible water gas shift equilibrium. Above about 400°C., a good catalyst permits the residual carbon monoxide to be brought almost as low as the equilibrium minimum, which varies mainly with the excess of steam present and the temperature in the outlet zones of the catalyst bed.

With 100 moles steam initially present and a preheat temperature of 340°, the temperature in a single well-lagged catalyst vessel will rise to about 500°C. and the equilibrium carbon monoxide will be 5 moles. If a higher degree of removal is required, either more steam may be used, or the treated gas may be cooled to about 390°C. and passed through a second catalyst vessel so that the composition can approach equilibrium at about 400°C. By either method, the minimum residual carbon monoxide can be as low as 2%, but at a higher cost. In this paper, a reduction of the carbon monoxide to about 5% is assumed to be satisfactory.

Change of gravity

The water gas shift reaction results in the replacement of carbon monoxide by equivalent volumes of carbon dioxide and hydrogen. Since hydrogen and carbon monoxide have approximately the same calorific value, the thermal value of the gas per unit volume of the original gas is virtually unaltered and the calorific value of the converted gas decreases inversely as the change in volume. The extra volume of gas made has the same gravity as the steam that has reacted, that is, .623. There is, therefore, a change of gravity towards this figure, the change being small when the initial gravity differs little from .623 as in the case for carburetted water gas manufactured from gas oil.

Abstract and discussion of a paper to the Institution of Gas Engineers in November, 1959.

Removal of carbon dioxide from the converted gas is accompanied by an increase in calorific value and a decrease in gravity. If the treated gas is to have a specified calorific value and gravity, then the two variables, the degree of conversion and the degree of carbon dioxide removal, are uniquely determined. To satisfy both the calorific value and the gravity requirements and to reduce the carbon monoxide to a definite level, a third degree of freedom is necessary, namely, the addition of some form of cold enrichment such as butane, or admixture with rich coke oven gas. Alternatively, the carburetted water gas could be produced with a higher calorific value, but the high hydrocarbon content of such gases would make them less suitable for treatment.

The results obtained at Basle indicate that, when treating coke oven gas, the catalyst life is adequate if the nitric oxide content of the gas is reduced to a low value. But the rate of fouling on carburetted water gas may be significantly different because the concentration of fouling constituents is different. Compared with coke oven gas, carburetted water gas contained 2.3 times the concentration of olefins and 4.1 times the concentration of conjugated diolefins. On the other hand, the nitric oxide concentration in carburetted water gas is usually lower than that in coke oven gas; this may counterbalance the effect of the higher hydrocarbon content.

In each test, 100 moles of steam were added to 100 moles of water gas and the mixture passed over 10 cc. of catalyst at a space velocity of 500 volumes of water gas per volume of catalyst per hour. In the first set of tests, the three catalysts used were commercial chromia-promoted iron oxide.

The laboratory tests show that fouling is rapid with gas containing nitric oxide, oxygen and conjugated diolefins and that acetylene also contributes to the loss in catalytic activity. However, the tests on carburetted water gas indicate that the life of an unprotected catalyst may be quite long; this is probably due to the relatively low nitric oxide content, about .1 ppm. of the carburetted water gas treated.

Purification processes at present established in the gas industry deal with low concentrations of impurities such as ammonia and hydrogen sulphide. On the other hand, the concentration of carbon dioxide in shifted water gas is in excess of 25%, and, for a 10 mill. cu.ft. per day stream, the degree of removal indicated corresponds to quantities of the order of 100 tons per day. By comparison, complete removal of 500 grains per 100 cu.ft. of hydrogen sulphide would yield 3.2 tons per day from this make of gas. The magnitude of the quantity involved is one of the factors that contribute to the high cost of carbon dioxide removal.

No credit anticipated

Many of the existing methods of carbon dioxide removal have been developed to meet the requirements of the synthetic ammonia industry. The hydrogen produced must be of high purity; the gas is compressed finally to 300 atmospheres and a relatively high production cost per therm of hydrogen can be tolerated. In contrast, the gas industry may allow a high slip of carbon dioxide, but the process must be cheap and this means avoiding compression, if possible. Other methods have been developed to recover carbon dioxide from flue gas for sale in gaseous or solid form and for the production of controlled atmospheres for metallurgical purposes. The objective is the economic recovery of the carbon dioxide in an uncontaminated state, or, in the second instance, the production of nitrogen with a high degree of purity. Again the emphasis is different, since in each case a product is produced that commands a high price relative to fuel gas. No credit can be anticipated for the carbon dioxide removed by the gas industry, since, with a recovery of 10 tons per mill. cu.ft. of gas treated, saturation of the market would soon be achieved.

The available methods of carbon dioxide removal may be classified as (*a*) gaseous diffusion, (*b*) adsorption by molecular sieves, (*c*) absorption by solid reagents, (*d*) physical absorption in liquid solvents, (*e*) chemical absorption in liquid reagents and (*f*) refrigeration.

Survey conclusion

From a thorough survey of these methods, it became apparent that there is no existing process capable of the partial removal of carbon dioxide at very low cost. Of the three most widely used processes, water wash, hot potash and monoethanolamine (M.E.A.) scrubbing, the first two are economic only at pressures in excess of 200 p.s.i.g., which imposes a minimum cost for compression in excess of .5d. per therm. M.E.A. has a great affinity for carbon dioxide, the heat of absorption and the boiling-point are high, and these facts combine to make the cost of regeneration high. Secondly, the reagent is expensive and losses occur both by vaporisation and chemical change.

Two possible exceptions among the reagents reviewed are activated potassium carbonate and ammonia at a higher concentration and degree of carbonation than those quoted in a recent article. In view of the lack of publication of basic physical data relating to the absorption of carbon dioxide into activated potash solutions, further laboratory work is necessary before the processes can be evaluated. There is, on the other hand, a profusion of published data on the absorption of carbon dioxide into ammonia solutions, so it was decided to make a design study of a possible process, to erect a small pilot plant to check the validity of the assumptions made and to observe any practical difficulties that might arise.

DISCUSSION

Mr. G. E. Currier, O.B.E., North Eastern Gas Board: The paper is concerned solely with the application of the shift reaction to carburetted water gas. It is understandable that the research was directed to carburetted water gas seeing that it contains the highest content of CO—approximately 30%—and that considerable quantities of carburetted water gas are made in this country. Also the shift reaction process has been proved to be technically sound in the large scale operation of the plant at Basle dealing with coal gas from coke ovens plus producer gas and where the carbon monoxide is reduced from 11% to 1%.

It is interesting to learn from the authors that a commercial chromia-promoted iron oxide catalyst can give satisfactory results and that tests indicate that with carburetted water gas the life of the unprotected catalyst may be quite long. This is thought to be due to the low nitric oxide content, which is of the order of .1 p.p.m. Incidentally the nitric oxide content of the gas at Basle is .4-.6 p.p.m.

The fouling of the catalyst is said to be due to the interaction of conjugated di-olefins, nitric oxide and oxygen on the surface of the catalyst. It would seem that nitric oxide has more serious effects on the catalyst than the hydrocarbons.

One disadvantage in dealing with carburetted water gas is the high hydrocarbon content and its effect on the catalyst, but the gas has the advantage of having a lower nitric oxide content than coal gas.

The large scale plant at Basle uses water gas shift reactors. It is interesting to know that the difficulties in

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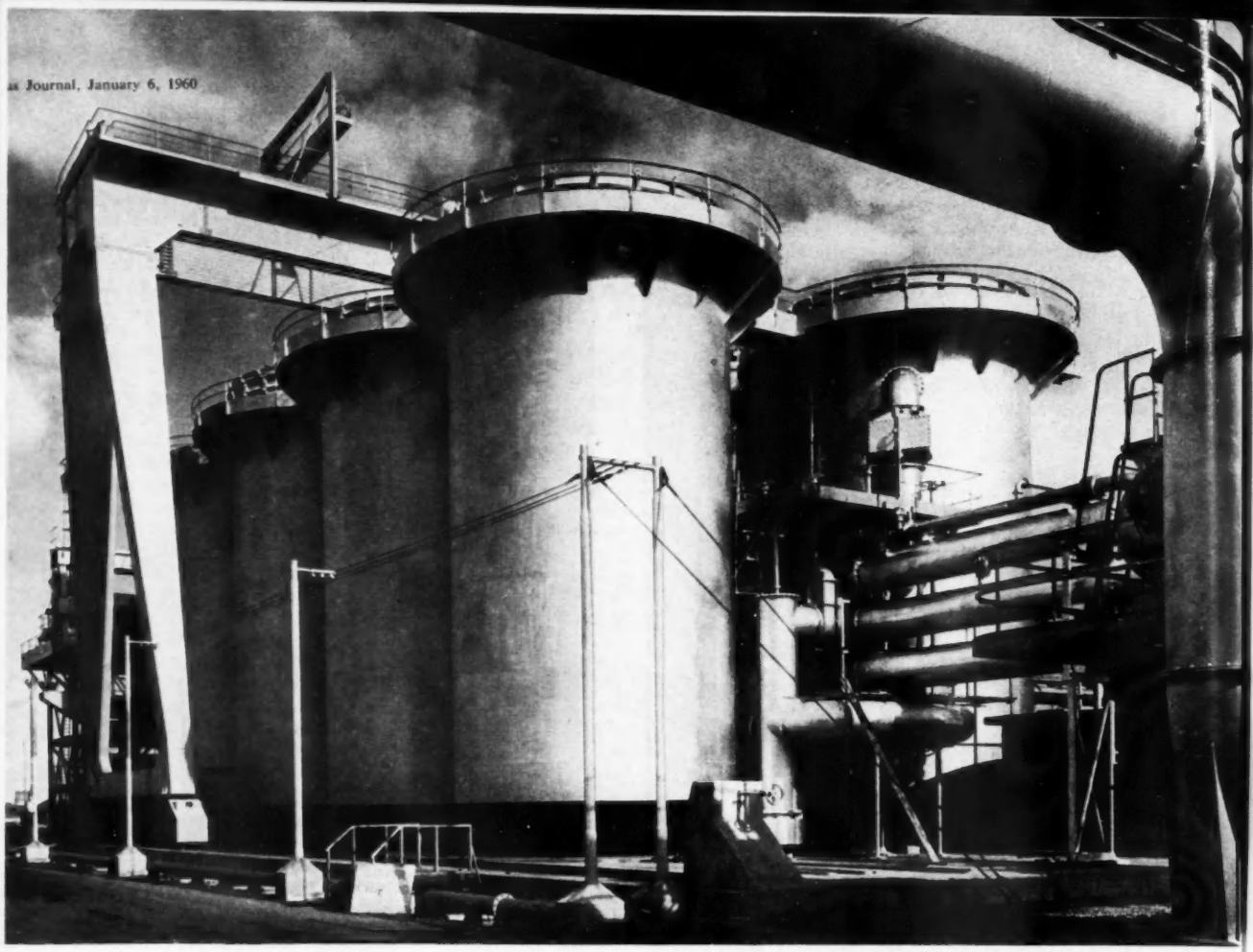

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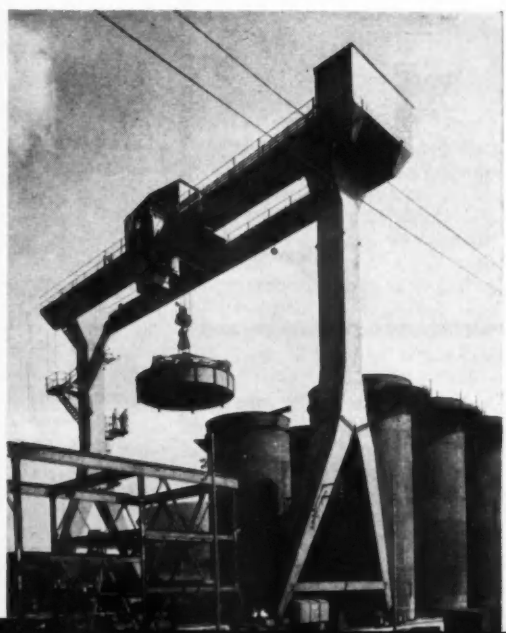

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the early days of this plant, mainly due to nitric oxide causing deterioration of the catalyst have been overcome by the use of a special pre-treatment catalyst.

In this country some carburetted water gas plants are in continuous operation, but the majority work intermittently. I believe it is better to work the water gas shift reaction process continuously, and this could be done more easily with coal gas than with carburetted water gas. It may, therefore, be found advisable to reduce the carbon monoxide content of the coal gas and leave the carburetted water gas untreated. If the carbon monoxide in the coal gas were reduced to 1% then with a mixture of carburetted water gas (untreated) up to 30%, the carbon monoxide in the mixed gases would range from just under 10% downwards.

The new production processes and new gases will have a very low or nil CO content, and therefore it would only be necessary to apply the shift reaction process to a number of existing plants, which are likely to continue in operation for some years.

One most important advantage of this process is the considerable reduction in organic sulphur, for which full credit should be given.

The authors have carried out a considerable amount of work on the removal of carbon dioxide following the shift reaction, and have found that a solution of ammonia or activated potash give promising results. They wisely suggest that with only partial removal of carbon dioxide it would be better to treat a portion of the shifted gas for the maximum removal of carbon dioxide.

Limited information

I may add that I am chairman of a committee of the International Gas Union which is studying safety in all its aspects in the utilisation of gas in domestic, commercial and industrial appliances. An attempt has been made to obtain a correlation between the carbon monoxide content of town gas and the number of fatalities. Information on this subject is somewhat limited and when available it is not always certain that comparable conditions exist in regard to the circumstances leading to the fatalities or to the statistical treatment of the numbers involved.

Even with complete removal of carbon monoxide there would still remain the hazards of fire, explosion or asphyxia, but these are usually much less in number, but vary considerably in different countries.

On the other hand the application of safety protective devices to gas appliances will not give complete immunity from accident. It may well be that a combination of these practices, i.e, reducing the carbon monoxide content and the provision of automatic ignition and other protective devices to gas appliances may provide the solution to this problem.

Mr. S. K. Hawthorn, West Midlands Gas Board: The objective of this excellent piece of work is to make carburetted water gas less toxic and to enable is to be used to a greater extent for base load production. If it can be successfully and economically translated to full scale operation, it will be of great importance to the gas industry.

By means of the conversion process, it is most convenient to reach a CO content of about 5% which is, of course, considerably lower than is normal in town gas. There may, however, be a good case, as a preliminary step, to aim for the same CO content in water gas as is usual in coal gas and take no steps to reduce the CO_2; the calorific value could be restored by additional enrichment and incidentally the thermal output of the water gas plant would be enhanced.

It is probably not practicable to operate the conversion process directly to give a CO content of say 15%, but it would be reasonable to treat part of the water gas down to 5% CO, leaving the CO_2, and mixing back with suitably enriched water gas to give the desired final calorific value and a CO content similar to coal gas with a CO_2 figure of 16 to 18%.

It is shown in [Table I of the paper] that water gas produced with light distillate with CO conversion down to 5% and with CO_2 left in, is still as low or lower in specific gravity for a given calorific value than carburetted water gas made from gas oil, presuming that the light distillate is used for reforming as well as enriching. In this case, too, the CO_2 content would be 11 to 12% for a mixed gas with a CO content of 15%.

Increased thermal yield

A further important point in favour of leaving the CO_2 in the gas, is the increased thermal yield obtainable from a water gas plant for a given final calorific value without materially increasing the volume of gas produced in the machine itself. There would thus be no increased loading of ancillary plant except for the removal of residual H_2S formed in the conversion process. Increased thermal capacity of a water gas plant might be a significant credit to set against the capital cost of conversion plant.

Perhaps the authors do not fully appreciate the implications of a successful development of their work on the coke problem now facing the industry. Water gas production is frequently restricted because of the resultant raising of the CO content in town gas. With this restriction removed, the coke situation could be more readily controlled by producing more water gas, i.e., by switching part of the water-gas plant to base load operation. Furthermore, with an increased thermal output per machine on account of additional enrichment it may be possible to use No. 3 coke—which would normally reduce gas making capacity—and still maintain the rated output per machine.

Water-gas produced from light distillate, with partial CO conversion and no CO_2 removal may be quite as cheap as normal carburetted water gas with gas oil enrichment because of the price difference between light distillate and gas oil. The suggestion is that a switch from gas oil to light distillate may pay for the cost of CO conversion. It would also appear that increased enriching by light distillate should be much cheaper than cold enrichment with butane.

The final aim of applying CO/CO_2 conversion to carburetted water gas and perhaps subsequently to coal gas is undoubtedly a low CO concentration in town gas. I am only suggesting that a limited application as a first stage may not be difficult or costly and could play an important role in balancing coke production with coke sales, and this, as we all know, is an urgent problem.

Dr. L. A. Moignard, the Gas Council, Midlands Research Station: The authors have dealt concisely, and with a most helpful Table on [p. 7], with the readjustment of density and calorific value that will have to follow carbon monoxide conversion.

The work has clearly been started because it is felt that foreign experience does not take us far enough towards cheap and trouble-free catalysts suitable for c.w.g. streams where the fouling problems arising from unsaturated hydrocarbons may be more acute than in a carbonisation gas. One can see from [Table 4] that many substances have been examined and it would be interesting to know what chemical principles underlay the choice of some of them. One can ask more particular questions, too; such as, why the precipitate from ferrous sulphate and liquor, which was no doubt allowed to oxidise, appears so much inferior to α-ferric oxide monohydrate. Perhaps the figures

that would help most in the consideration of the Table are the maximum theoretical, i.e., equilibrium, conversions at each temperature. The figure falls as the temperature rises and in the light of this the lower figure at 450° than at 400° for the dichromate-activated ferric-oxide monohydrate might seem less peculiar.

The authors rightly say that the catalyst should be sulphur resistant and should convert organic sulphur to hydrogen sulphide and I wonder what their proposals are for the final purification of the gas from this constituent. They do not mention the possibility, but there would be attraction in doing the conversion before the normal purifiers so that H_2S removal is done once and for all and a clean gas goes forward to the carbon dioxide removal unit. They may have turned away from this approach because of the lower activity of the catalyst in a high concentration of hydrogen sulphide and because the conversion of organic sulphur compounds would suffer. It has also been said that fluctuating concentrations of hydrogen sulphide hasten the physical deterioration of the catalyst.

Carbon deposition

The authors mention carbon deposition only in connection with decomposition of hydrocarbons. They are, of course, aware that the input gas is far on the wrong side of equilibrium for the formation of carbon and carbon dioxide from the monoxide, and that the result of this reaction setting in would be the immediate blocking of their reaction vessels. I wonder whether they agree that carbon deposition is prevented by the absence of free metal and by sulphidation of the oxide catalyst.

The studies on fouling have served to pinpoint the troublesome compounds but perhaps most practical interest attaches to the life tests, mentioned on [p. 13], which are making highly satisfactory progress. It is interesting to see that one is being tried without a protective catalyst in front.

I welcome the authors' concise summary of carbon dioxide removal methods although I think fuller discussion of the diagram on [p. 17] would have been helpful. They have commented wisely on the rather limited amount of independent concrete information which is available about the performance of ethanolamines, alkazide liquors, and the rest of the reagents which have come in for carbon dioxide—and hydrogen sulphide—removal in the last 20 or 30 years, as regards corrosion, vaporisation losses, side reactions and heat requirements for regeneration. Detailed and dispassionate information on these topics is indeed difficult to find.

Ammonia process preferred

The authors' imply that to compress the gas specifically for carbon dioxide removal is economically impossible and of course this limits their field of choice. They are inclined to plump for an ammonia process and we shall all look forward to hearing more about their experimental work in this and all other associated topics.

As many of you know, we are working at Solihull on carbon monoxide conversion and carbon dioxide removal under pressure, since, as the authors mention on [p. 4], such stages are an integral part of high pressure processes and would be included even if carbon monoxide were harmless.

Mr. W. B. S. Newling, London Research Station; Current trends in gas-making practice, irrespective of considerations of carbon monoxide removal, demand the standardization of heavier gravities for distributed gas.

Group 4 is the nominal standard in many areas, but in cold weather group 5 gas is sent out and is accepted by the appliances; the proportion of the heavier gas tends to increase from year to year.

It seems desirable to narrow the range of qualities sent out, by adopting group 5 as standard. This would mean that coal gas would always have to be mixed with heavier gases. It also means that c.w.g. made with petroleum spirit could be distributed without admixture with lighter gases. Most of the problem of gravity control would be transferred from the periods of peak demand to the easier period in the summer.

With group 5 as standard, even those works with a high make of c.w.g. would in most cases have enough coal gas to permit catalytic conversion of carbon monoxide without subsequent removal of carbon dioxide. Only in special cases, or to give an extra degree of freedom in controlling gas quality, would it be necessary to effect partial removal of carbon dioxide; in no case would more than 50% removal be needed.

Mr. K. W. Francombe, Whessoe Ltd.: Those of us who have been making a study of the removal of CO from carburetted water gas cannot fail to be grateful to the Director and staff of the London Research Station and especially to the authors for the immense amount of valuable information they have now provided. Most of the questions that everyone has been asking are answered in this paper. The most suitable catalysts, the fate of the unsaturated hydrocarbons, the hydrogenation of the organic sulphur compounds, the problems of CO_2 removal —all these and many more questions have been thoroughly investigated in the typically competent Fulham manner.

Effect on catalysts

One aspect which does not seem to have been fully covered is what effect the presence of various concentrations of H_2S might have on the catalysts. As the ferric oxide to ferric sulphide reaction is reversible, one might hope that in the presence of the excess water vapour needed for CO conversion, there would be a minimum production of sulphide and hence fouling of the catalyst, the H_2S passing forward unchanged. If this were so it would be splendid in that it might allow the gas to be purified of H_2S *after* CO conversion, instead of both before and after as is now considered desirable.

But might the presence of 100 to 150 grains of H_2S per 100 cu.ft. in unpurified carburetted water gas inhibit the hydrogenation of the organic sulphur compounds to H_2S, thereby detracting from the bonus of organic sulphur removal on top of detoxification? The additional cost of final H_2S removal after shift-conversion, although normally only involving around 10 grains H_2S, is quite appreciable, as it is too much for zinc reagent washing, so it would be fine if the existing purifiers could follow rather than precede the shift converter.

During the past 12 months, my company has been studying CO reduction plant, on the assumption that a suitable catalyst is, or can be made available, which will stand up to the unsaturated hydrocarbons present in carburetted water gas. I think it may be worth quoting preliminary figures if only to indicate that partial detoxification is not a pipe-dream, but can be accomplished at a cost which makes the present paper of very real practical significance to gas engineers.

It appears that a sizeable plant—say of the order of 20 mill. cu.ft. per day—would cost around £15,000 or so, per mill. cu.ft. of gas per day, including final H_2S removal, but excluding CO_2 removal which may not be necessary. To put this another way, it is unlikely that the capital charges would exceed .25d. per therm, and as the operating charges add about another .35d. per therm, the total

cost is around .6d. per therm. Even if one prudently raises this to .75d. per therm, as these things do often seem to cost more than anyone can predict, it would still seem an economic possibility, as such carburetted water gas if diluted with an equal volume of untreated coal gas, would provide town gas of greatly reduced CO and organic sulphur at, say, ¼d. per therm additional cost. This might be more than offset by the reduced cost of carburetted water gas when using light distillate instead of gas oil.

Mr. D. G. Worgas, I.C.I.: As the paper points out, in the chemical industry we have been carrying on this reaction for many years on a very large scale. In this country alone about 200 mill. cu.ft. per day are passed through these water gas shift reactors. In the chemical industry also we are dealing with what I would call clean gases, and the commercially available catalysts which have been tested in the paper, one of which we have been making ourselves for 25 years, are poisoned by these constituents in town gas.

The paper has very usefully discovered a catalyst which will turn these catalyst poisons into something innocuous so that the catalysts which are commercially available can be used on town gas.

Reactions of the catalysts

The paper has dealt very adequately with the chemical reactions which occur in the gases, and one of the previous speakers touched on a subject which I should like to refer to, namely, what happens to the catalyst during this water gas shift reaction? The standard definition of catalyst is something which is not changed during reaction, but that is exactly the reverse of what happens here. During reaction the catalyst here is converted either to $FeSO_4$ or FeS, and there are a number of important reactions between iron oxides, carbon dioxide and hydrogen which affect the handling of catalysts during operation.

There are three main headings under which one can consider the reactions of the catalyst. These are iron, carbon and oxygen, iron, hydrogen and oxygen, iron, sulphur, hydrogen and oxygen. Most of the reactions are highly exothermic so it is necessary to take care that temperatures do not get out of control. There are about 23 possible reactions which go on, an important one being the conversion of Fe_2O_3 with carbon monoxide to $FeSO_4$ during the heating up period. That is a highly exothermic reaction, and the carbon monoxide must be kept to 15% or less in the gas otherwise temperature will get too high. If you have hydrogen it should be used. In operation the catalyst can either be Fe_3O_4 or FeS, and catalyst activity is reduced to about half when the catalyst is sulphided. One must not oxidise the sulphided catalyst with oxygen because instead of obtaining the desired reaction FeS, one gets ferric sulphate formed which is a completely inactive catalyst. Another point about this is that stable iron oxide in the normal temperature range, which is 300 to 350°C., is Fe_3O_4.

From our experience in I.C.I. if you use the catalysts you should make a thorough study of the chemistry in order to avoid some of the mishaps which I have seen happen when passing air over a reduced catalyst.

Mr. J. A. Prigg, Watson House: Our interest in this paper at Watson House is in the combustion characteristics of the gases that can be produced by the conversion or removal of carbon monoxide.

In general, when the carbon monoxide in a gas is converted by the shift reaction and the gas enriched back to its original calorific value with a hydrocarbon, the resultant gas has similar combustion characteristics to that from which it is derived. However, both the Wobbe number and the flame speed are reduced—the extent of the reduction depending upon the original gas and the hydrocarbon used for enrichment.

The carbon dioxide left in the gas appears to have no adverse effect on combustion. There is, for example, no increase in the production of carbon monoxide when such gases are burnt in appliances. We have found that gases containing carbon dioxide tend to have higher aeration numbers than would be expected from their Wobbe numbers and flame speeds, but this may be an advantage in certain cases.

The removal of carbon dioxide by washing increases the Wobbe number and flame speed so that a whole new range of gases are produced which can be used where high Wobbe numbers and flame speeds are an advantage.

In [Table 1] the authors illustrate these points by considering the conversion of two varieties of carburetted water gas, and by considering how much carbon dioxide need be removed to produce gases in gas groups G4, G5 and G6.

The enriching agent used is butane, and it will be seen that the enriched converted gases containing all the carbon dioxide produced in the reaction have lower Wobbe numbers than the original gases. Nevertheless, these Wobbe numbers are within the same gas groups, and as the flame speeds are similar, the original and converted gases are interchangeable.

If hydrocarbons other than butane were used for enrichment the converted gases produced would be rather more acceptable since their Wobbe numbers would be higher. For example, with the converted carburetted water gas produced from gas oil the Wobbe number using butane enrichment is 601 while if methane enrichment were used it would be 628, that is a little higher than the original carburetted water gas at 624. The aeration number of the methane enriched gas, too, would be higher, and advantage with hard gases such as carburetted water gas which have a tendency to light back on aerated burners.

Carburetted water gas, however, is not often used alone but is more frequently mixed with a coal gas. The converted and enriched gases with no carbon dioxide removed, generally, require more coal gas to raise them to a given Wobbe number, but on the whole, this extra gas is not great, and in fact using methane enrichment with the converted carburetted water gas from gas oil, shown in [Table 1], more of this gas can be used than of the original carburetted water gas.

Acceptable gases

For example, if we assume that the carburetted water gas is usually mixed wth 50% coal gas of the same calorific value to produce a gas of Wobbe number 680 then 42% of the converted gas enriched with butane would be needed to give the same Wobbe number and 54% of the gas enriched with methane. Converted gas enriched with other gaseous hydrocarbons would require intermediate quantities.

Thus it will be seen that acceptable gases can be produced by converting and enriching these gases without removing the carbon dioxide produced in the process.

Nevertheless, the removal of carbon dioxide provides a range of gases from carburetted water gas which have lower specific gravities and higher burning velocities than the original gas, and these converted and washed gases might therefore be used in admixture with various slow burning heavy gases to produce gases interchangeable with the present supplies, thus greatly increasing the flexibility of gas manufacture.

Mr. J. Milner, Humphreys & Glasgow, Ltd.: I have been encouraged to hear from the authors of the prospects

of their proposed ammonia liquor technique for removing CO_2 economically at atmospheric pressure, since existing CO_2 removal processes are costly. In fact, my company closely studied the Hameln and Nordhausen installations before the second world war and concluded that the gas industry was unlikely to adopt CO conversion at that time, largely because of this ancillary cost.

Arising from a specific enquiry from the Northern Gas Board last year, my company built a small pilot adiabatic converter to operate on carburetted water gas at the Redheugh works. Past experience of CO conversion in coal gas suggested that a guard catalyst would be required since carburetted water gas, and incidentally, Onia-Gegi gas also, contains a higher proportion of unsaturated constituents and also a higher CO content which leads to a greater temperature rise in the catalyst. The first experiment with carburetted water gas at Redheugh quickly confirmed this and, without a guard catalyst, the useful life of the shift catalyst was only about a week. Using a cobalt-molybdenum-alumina guard catalyst made by the manufacturer of the conversion catalyst, this life was only prolonged to six weeks, whereas working with blue gas, which can be regarded from the catalyst's point of view as a 'sterile' material, this same shift catalyst would be expected to retain its activity for five to ten years. One interesting point in this work was the care needed to analyse the minute quantities of O_2 and NO which are involved.

Work was then transferred to the laboratory where gas has been made on a continuous basis by carburetting cylinder blue gas with gas oil. In ordinary plants the proportions of the dangerous components in carburetted water gas can vary substantially with differing raw materials and methods of operation, and to ensure that the laboratory tests were carried out under the most stringent conditions, the gas was dosed with NO to 1 ppm., with organic sulphur to a total of 10 grains per 100 cu.ft. and with O_2 to .3 to .4%. Care was also taken to minimise the residence time between the carburettor and the converter to prevent the normal gum forming reactions from occuring before the gas reached the catalysts. This was considered important because one of the Redheugh experiments had shown that, during a period when gas which had been stagnant for a considerable time in a holder was used instead of freshly made gas, there was a steady improvement in conversion. This indicated that the harmful compounds had been removed from the gas and is, of course, in line with the industry's general experience of gum formation.

These laboratory experiments have again shown that the unprotected shift catalyst can be rendered useless in as little as a week's working, but they have also shown that there are several pre-catalysts which will prolong this period substantially, among them the nickel subsulphide described in this paper. These life tests are still continuing successfully and it is hoped that they will help to contribute something more to the interesting work described by the authors.

Finally, I should like to ask the authors if they have found SO_2 in the gas leaving their nickel subsulphide pre-catalyst as was the case at the Harrow organic sulphur removal plant which used this catalyst.

REMOVING HYDROGEN SULPHIDE BY LIQUID PURIFICATION

From p. 24

ammonia, is passed into the oxidisers at the bottom. The following action, aided by the catalyst, occurs:

$$2\,H_2S + O_2 = 2\,H_2O + 2\,S.$$

The sulphur is precipitated as a foam, the solid being suspended in a very fine state of suspension in the liquid, and air, liquor and catalyst pass away together to a tank and filter (E). The sulphur removed on the filter is washed to remove soluble salts, and taken to an autoclave (F) where it is melted, separated from remaining water, and cast into blocks.

The mechanism of removal of H_2S from gas by this process is interesting in that it follows the schemes of 50 years ago, in which ammonia was suggested and used as the washing medium. Whereas these processes were, in general, unsuccessful, the Perox system possesses the radical feature of continuous removal of H_2S externally through the medium of the catalyst. This enables continuous regeneration of the washing medium to take place with consequent greatly increased scrubbing efficiency.

Results, typical of the process, are shown in Table 1.

TABLE 1

Impurity	Crude gas at outlet exhausters	Gas at outlet of Perox scrubber
H_2S	400	.1 to .5
NH_3	360	300
HCN	50	1 to 2

After treatment in the scrubber, the gas is passed through a washer for the final removal of ammonia, H_2S being also extracted to the extent of about half of its concentration at the outlet of the Perox scrubber.

To obtain maximum efficiency, it is important to maintain favourable temperature conditions in the plant. The reaction whereby free sulphur is formed from H_2S is exothermic, so that an increase in temperature will take place in the oxidiser.

This has the undesirable effect of heating the liquor which is circulated in the scrubber, since it causes dissociation of ammonium sulphides and hydrosulphides, thus maintaining an excessive vapour pressure of H_2S in the washed gas. On this account the oxidising columns are constructed with air-cooled radiating surfaces which, in cold weather, will generally have the effect of dissipating the heat of reaction, but in hot weather it is usually necessary to cool the medium before it enters at the top of the scrubber. This may be carried out by a water-cooled heat exchanger.

The oxidising reactions produce a considerable amount of water, which dilutes the catalytic washing medium. In order to counteract this, the temperature of the crude gas entering the scrubber is maintained at a few degrees lower than that of the oxidiser, so that the gas is, at a later stage, enabled to pick up and carry away water vapour from the catalyst liquor. By adjusting gas and liquor temperatures, it is possible to reach a satisfactory balance between the quantities of water formed in the oxidiser and water vapour taken up by the gas in the scrubber.

A special cooler (G) fed with water at a low temperature is generally used for cooling the condenser (A). Addition of fresh water to the washing and cooling water in this condenser enables the ammonia concentration in the gas to be set at the optimum value.

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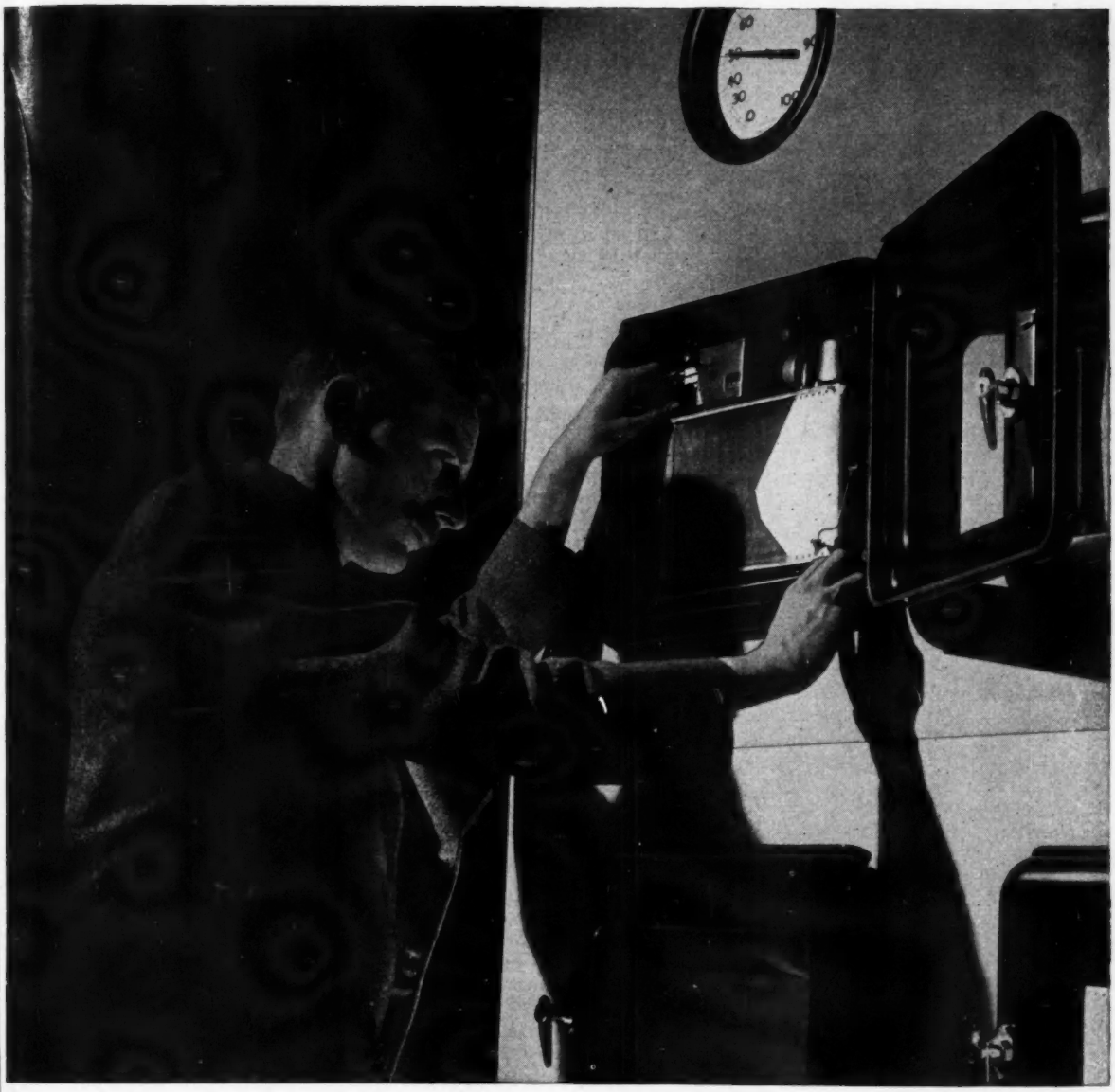

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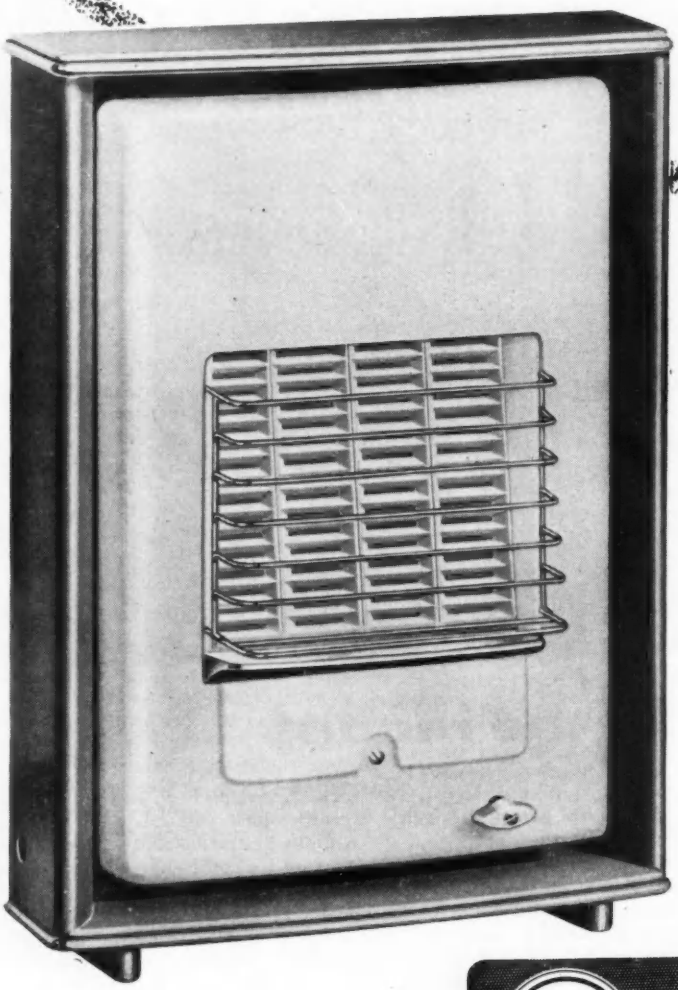

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Technical developments

Slow-speed motor

THE designers and manufacturers of the Staffa range of hydraulic equipment and tube-bending machines, reports a newcomer designated the Staffa Mark V to its range of slow-speed hydraulic motors. The new motor has seven cylinders, each having a bore diameter of 4-in. and a stroke of 3-in. While the general design is similar to the well-known five-cylinder type, the crankcase and cylinders of the Staffa Mark V form a monobloc casting, with the seven cylinders arranged radially and each fitted with a detachable head. At the normal working pressure of 2,000 p.s.i. the manufacturers state that the maximum output torque is 6,650 lb. ft. with an overall efficiency rating of 94.2%. The speed range is 0-75 r.p.m. and the driving shaft may be safely loaded to six tons overhang weight. For starting and peakloading, the pressure can be increased to 3,000 p.s.i., giving an increased output torque of 10,000 lb. ft.

The Staffa Mark V.

The new motor is already installed in several coal-mining applications in this country. In America it is being used for dredgers, earth drilling augers, conveyors, steel rolling mills, cranes and winches. Like the original five-cylinder type, the speed of the Mark V is infinitely variable within the stated range, and in either direction of rotation. —*Chamberlain Industries Ltd.*

Welding process

AN application of the Rockweld carbon dioxide welding process (the Comet process) is becoming of increasing interest to many fabricators. It is the semi-automatic butt welding of horizontal seams in vertical plate work at currents of 400-450 amps. The weld can be carried out with one pass.

This application is of particular importance to fabricators carrying out site or shop welding of extremely large components which do not lend themselves to being positioned for downhand welding. In such circumstances, this Comet application is said to enable work to be carried out about three times as fast as previous methods.

In the Comet Process the arc is struck between a special composite continuous wire and the workpiece in an atmosphere of carbon dioxide gas. The wire contains the deoxiding agents and slag-forming materials, the carbon dioxide protecting the metal from atmospheric contamination during transfer and in the weld pool. It is, therefore, a visible arc process, readily adaptable for both automatic and semi-automatic operation.—*Rockweld Ltd.*

Self-priming pump

THE Pep-Loewe range of centrifugal pumps has been increased by the addition of a new vertical self-priming unit, the VRL.225. The new pump is robustly designed for general purpose pumping duties and is suitable for handling clear or cloudy liquids up to 220°F. fuel and diesel oils and other oils up to 450 seconds Redwood No. 1. Due to its self-priming characteristics it can be used to handle volatile liquids.

The VRL.225 is said to prime quickly, the dynamic suction lift amounting to as much as 28 ft. when pumping cold liquids. The capacities and heads available are 70 gal. per hour at 100 ft. of liquid and 400 gal. per hour at 25 ft. The pump occupies less than 1 sq.ft. which is of considerable advantage where a unit of comparable power has to be installed in a confined space.

The VRL.225 incorporates several new features. The casing is designed so that if the foot valve on the suction line should be inoperative the pump will continue to work. The impeller is specially shaped and is fitted with very short blades to prevent breakage on bending, and is also fixed so that it is not in contact at any point with the casing and there is consequently no wear on the impeller. The pump and motor shafts cannot become misaligned since they are rigidly coupled by a new type of special split coupling. The pump is normally fitted with a ½-h.p. three-phase motor but if required either single-phase a.c. or d.c. motors can be fitted.—*Precision Electrical Products (Stockport) Ltd.*

Merton Frontloader

THE Merton Frontloader 59, first introduced at the Building Plant Exhibition in June last year, is now available with torque converter power-shift transmission. The unit fitted is the well-tried Brockhouse hydraulic-shift single-stage torque converter which gives two forward and one reverse speeds of up to 5 and 10½ m.p.h. and 5½ m.p.h. respectively. The machine is powered by the latest type Fordson 4 cylinder 62 h.p. diesel unit.

The Merton Frontloader 59.

A robustly-constructed unit with excellent outreach for loading high-sided lorries or plant hoppers, the Frontloader has been especially designed to give the driver the maximum view of his work. The front mounted cab has all round 360° visibility and at all times the driver can see the digging edge of the bucket. Particularly impressive is the excellent stability of this latest Merton product especially on rough sites.—*Merton Engineering Co. Ltd.*

Midget arc-welders

THE small bulk of the Dohm Midget and Twin Midget electric arc-welding machines and their comparatively low weight make it no longer necessary for welding plant to remain static in a garage or engineering workshop because the Dohm Midget machines can be taken to the job. They have a maximum output of 160A on 50 open circuit voltage or 120A on 75 open circuit voltage. The Midget 200/250 volt input is available for use on single phase only. A model is also available for operation on one, two or three phase.

The Dohm Twin Midget 200/500-V input—suitable for operating on one, two or three phase, has 52 variations of output current on each range. When used by one operator the maximum output is 320A and when used by two operators it has a maximum output of 160A each operator. Dohm arc-welding machines are supplied complete with accessories.—*Dohm Ltd.*

Chromatographic detector

ORIGINALLY designed by Dr. D. W. Turner of the Imperial College, a new chromatographic detector is both robust and flexible in application, depending for its action upon changes in dielectric constant of the emergent stream which may be either gas or liquid. Changes in the electrical capacitance of a suitably designed cell are converted into corresponding voltage fluctuations by means of an adjoining unit.

The detector cell, unlike the catharometer need not be thermostatically controlled but may work at or above the column temperature. The convertor assembly is thermally insulated from the cell and its temperature remains low even when the cell reaches its normal maximum working temperature of approximately 250°C.

Comparable in sensitivity with the catharometer, this method of detection is absolutely independent of the rate of the gas flow. The instrument responds satisfactorily with such solvents of low dielectric constant as benzene, cyclohexane, toluene, tetralin, etc., and has wide application in industrial gas and liquid stream analysis in the petroleum, paint and essential oil industries, as well as to a variety of laboratory chromatographic separations.—*H. Tinsley & Co. Ltd.*

Safeguard relay

GAS burners can be controlled from a new electronic flame safeguard relay which uses the flame rectification principle and responds to both flame rod and photocell sensing elements. Besides providing the normal flame safeguard functions, it ensures that the burner cannot be started if any flame simulating fault is present. If a fault simulating flame does occur, the new protectorelay locks out on safety to prevent operation of the burner until the manual reset button has been actuated.

The flame rectification principle makes the screened lead, normally employed with this type of relay unnecessary, and the relay is safe with a shorted photocell/flame rod connection.

Easily installed and serviced this instrument can tolerate up to 100 ft. of lead to a flame rod, or 300 ft. to a photocell.—*Honeywell Controls Ltd.*

GAS JOURNAL

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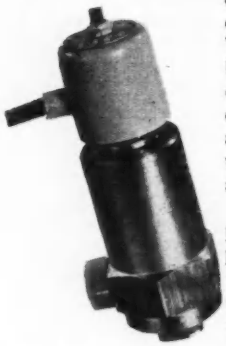
Details and coupons are given on the backing page

Solenoid valve

THE new Ether solenoid valve, type ASV, is designed for use in systems where an auxiliary pressure supply can be used to actuate a servo-device controlling the main valve. The auxiliary supply is controlled by a small three-way pilot solenoid-operated valve which, when it is energised, allows pressure to operate on a piston, which is integral with the main valve seating assembly.



There are two models; On one, pressure is applied to the top of the piston and the main valve closes when the pilot valve is energised; on the other, pressure is applied to the underside of the piston and the main valve opens when the pilot valve is energised. Main valve sizes up to 1-in. are available at pressures up to 500 p.s.i. depending on the auxiliary pressure supply available.—*Ether Ltd.*

'Chemical blanket'

HEAT-LOK is a new treatment providing a protective chemical blanket for hot immersion processing baths, which has resulted in greatly reduced heating costs, improved working conditions and a reduction in equipment maintenance. Consisting of two integral components, the Heat-Lok sealant, forming a protective blanket on the surface of the processing bath, and the Heat-Lok additive which is a surface activating agent in the processing solution itself. Heat-lok has no harmful effect on the coating characteristics of the processing solution.

Heat-Lok additive is replenished in direct proportion to the amount of replenishing chemical used for maintaining the specified concentration of the processing solution and Heat-Lok sealant is added as required to maintain an approximately ½-in. thick chemical blanket on the surface of the solution.

With a saving of up to 70% of the heating costs, the Heat-Lok layer blankets all steam vapours, fumes and heat, containing them within the bath itself and with the smaller demand for heat, maintenance on heating elements is correspondingly reduced. Exhaust system requirements can be cut to the minimum, if not completely eliminated and with corrosive elements held in the bath proper, corrosion of nearby equipment is minimised.—*The Pyrene Co. Ltd.*

Colour range card

A CARD showing the new colour range of gloss finishes in decorative and maintenance paints stocked by Donald MacPherson & Co. Ltd., is based on the BS.2660 range of colours, supplemented by an additional 20 strong colours, most of which are particularly suitable for exterior exposure and are fast to light.

In addition there is a new range of flat, eggshell and emulsion paint finishes comprising 40 colours plus black and white and is again based on the BS.2660 range.—*Donald MacPherson & Co. Ltd.*

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WEST MIDLANDS STAFF CONFERENCE

NEWS SUPPLEMENT

Chairman anticipates surplus this year

THE West Midlands Gas Board looks like having a useful surplus for the second year in succession, the Board's Chairman, Mr. G. le B. Diamond, has announced.

'We must not count our chickens before they are hatched, but if we have only a moderate winter with a little bit of snow, we shall be all right,' said Mr. Diamond, who was addressing the annual staff conference at Wolverhampton on December 17. 'If we get a really cold winter, we shall come out tops.'

The Chairman said that sales in the earlier part of 1959 were down a little but that was not surprising in view of the exceptionally fine summer.

Changed circumstances

There had also been a big change in the circumstances in the fuel industry and a lot more competition was being experienced from oil, particularly for space heating, heavy billet heating and things of that kind. Sales of coke for space heating had taken the biggest knock from oil but he did not think the increase in oil consumption accounted for more than 2% of the national fuel budget.

Referring to coal, the Chairman said the Government and the National Coal Board may have gone a bit too far in their policy of retrenchment. They had possibly not taken fully into account the effects of two mild winters and a very warm summer.

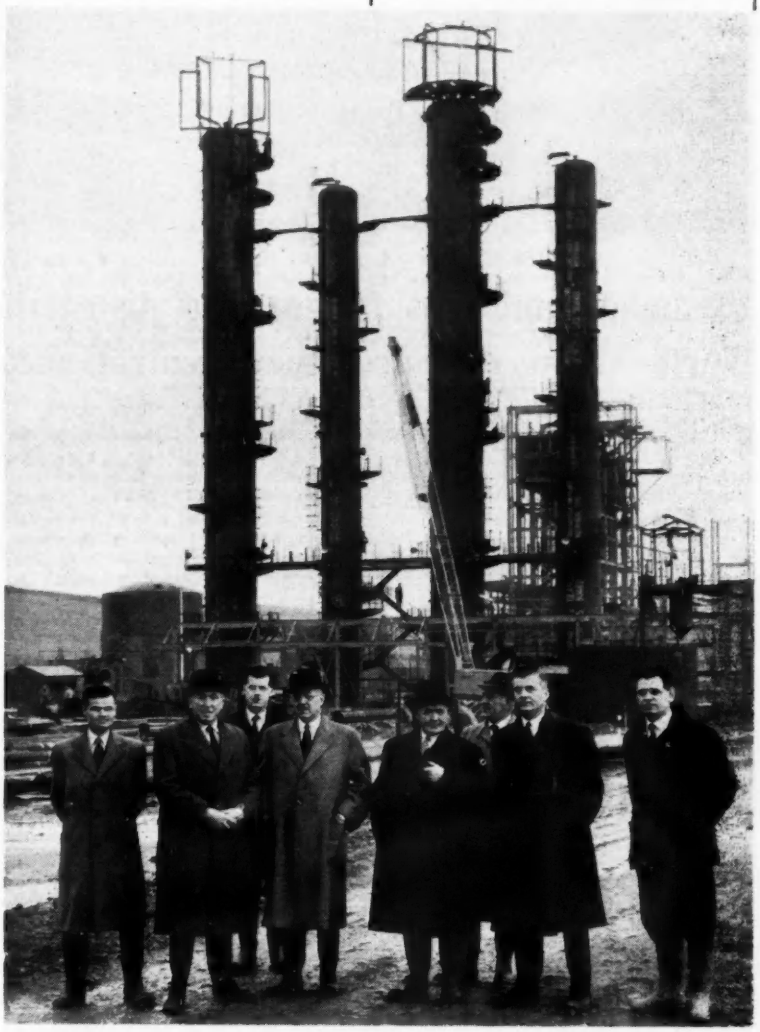
'Wait until we get 9 in. of snow and then see what will happen,' said Mr. Diamond. 'Delivery will then become the big problem. It is doubtful if deliveries will be able to keep pace with the orders and everybody will be putting on their gas cookers to use as central heating units. We shall have to be ready for it.'

Turning to the advent of atomic energy, the Chairman said that when he ventured an opinion four or five years ago that it was not too serious for the gas industry, a lot of people thought he was wrong.

'No competitor'

'The plain fact is that the atomic energy programme for power stations has gone wrong. One authority says that it is due to the Atomic Energy Authority assuming that nuclear power stations would be run at a load factor of 80%, whereas in Great Britain most of the power stations are running at under 50%. This is said to have thrown out all the calculations. It now seems unlikely that atomic energy will be a serious competitor for many years to come.'

SIR HAROLD SEES LURGI PLANT



AMONG Sir Harold Smith's last engagements before his retirement from the chairmanship of the Gas Council was a visit on December 22 to the site of the Lurgi pressure-gasification plant which the Scottish Gas Board are building at Westfield in Fife.

This group pictured at Westfield includes (second on the left) Sir Harold Smith, and, on his left, Mr. Sydney Smith, C.B.E., Chairman of the Scottish Gas Board, Mr. J. C. George, C.B.E., M.P., Parliamentary Secretary, the Ministry of Power, Mr. J. L. Warrander, Senior Scottish Officer of the Ministry of Power, and Mr. T. S. Ricketts, Chief Engineer of the Scottish Gas Board.

Planning minimises fatigue and distraction at North Western Board's new central accounts section

THE work of the North Western Gas Board's Accountancy Division has been centralised in an attractive and unusually-shaped modern single-storey building at Altrincham, Cheshire.

Here are housed an electronic computor and ancillary equipment which deal with gas and hire-purchase accounting for the Board's industrial and domestic consumers throughout the counties of Lancashire and Cheshire, and parts of Derbyshire and Cumberland.

The centre was designed by the Board's Architect, Mr. E. A. F. Taylor, in conjunction with the architects.

The main part of the building is based on an eleven-sided geometrical figure, with an open light well in the centre, and it was planned particularly to combat fatigue and distractions which can arise in a highly-mechanised accounting office. The space in the central light well is designed as a courtyard with a fountain and pond.

The central light well showing the fountain and pond in their setting of hexagonal paving slabs and shingle.

One of the primary requirements of the specification was that the building should be kept as dust-free as possible owing to the delicate mechanism of the computor, and to this end, an electrostatic filter unit was installed to filter the air for recirculation.

The circular building is clad on the exterior with Wallspan aluminium curtain walling supplied by Williams & Williams Ltd., and white and grey panels of Muroglass were used for infillings. These tone well with the aluminium sections of Noral 50 SWP alloy. There are no opening lights in the curtain walling owing to the air-conditioning system, each fast light being fitted with an aluminium-slatted Venetian blind, aluminium blind box and aluminium window sill.

The patented Unilock principle of slotting horizontal aluminium members into vertical members enabled the partitions to be formed into the curved corridor required by the radius of the building. The partitions were sound-insulated by double glazing, and a special dado panel, made up of a combination of perforated plastic sheets, plaster-board and glass-fibre quilts, provided the very high decibel reduction required.

The ceilings throughout are of aluminium acoustic tiles, supplied and fitted by Frenger Ceilings Ltd., and these incorporate aluminium ventilation louvres.

A spacious conference room tastefully decorated and furnished can, at short notice, be provided by opening folding screens.

PERSONAL NOTES

NEW YEAR HONOURS

Members of the gas industry to receive awards in the New Year Honours list include MR. EDWIN BAYLISS, J.P., D.L., Chairman, North Thames Gas Consultative Council, who receives the O.B.E.; MR. STANLEY GERVASE ABERDEIN, lately Commercial Manager, North Thames Gas Board, and MISS HILDA SWINDELLS, Chief Home Service Adviser, North Western Gas Board, who receive the M.B.E.; and MR. HARRY STANLEY ADAMS, Chargehand, Sheffield undertaking, East Midlands Gas Board, and MR. JOHN STEADMAN, General Foreman, East Greenwich gasworks, South Eastern Gas Board, who receive the B.E.M.

Other Honours of interest to the gas industry include MR. WILLIAM HENRY GLANVILLE, C.B., C.B.E., Director, Road Research Laboratory, Department of Scientific and Industrial Research, and MR. JOSEPH LATHAM, C.B.E., Deputy Chairman, National Coal Board (Kt.); MR. ROGER NATHANIEL QUIRK, Under-Secretary, Office of the Minister of Science (C.B.); MR. JOHN SHERWOOD HALES, Director, Industrial and Domestic Development Laboratories, British Coal Utilisation Research Association (O.B.E.); and MR. RICHARD LLEWELLYN LLOYD ROBINSON, Regional Fuel Engineer, National Industrial Fuel Efficiency Service (M.B.E).

MISS E. P. ALLEN has been appointed Assistant Secretary of the West Midlands Gas Board and thus becomes probably the only woman to hold such a post in a nationalised industry. Miss Allen was educated at Solihull High School and at St. Hilda's College, Oxford, where she took her B.A. degree with first class honours. Her first post was as assistant principal at the Ministry of Works. After leaving the Ministry she held various posts in the newspaper and publishing world and for a time was on the staff of the Newspaper Society. Miss Allen joined the West Midlands Gas Board as an administrative assistant in 1951 and has since been engaged in the Board secretariat.

SIR ARTHUR SMOUT, has resigned as part-time member of the West Midlands Gas Board. Sir Arthur, who is 71, was until recent years a director of I.C.I. He spent a long and distinguished career in Midland industry and has held many important public appointments. He joined the West Midlands Gas Board in May, 1953. The Board has passed a resolution thanking him for his services and wishing him well in the future.

MR. H. KERR, director-in-charge of the operating department of Woodall-Duckham Construction Co., Ltd., retired on December 31, from which date he resigned from the Board of the company. Mr. Kerr joined the staff of the company in 1929 and throughout his service has been associated with plant operation. He has held the position of head of the operating department for the past 20 years and joined the Board in 1949.

MR. ANDREW TRAILL, who has retired from the position of works engineer at Hamilton, was presented with retirement gifts from his colleagues by Mr. T. Grieve, Station Engineer for Hamilton and Uddingston. Mr. Traill went to Hamilton 13 years ago after service at St. Andrews, Forfar, Ayr and Berwick-on-Tweed.

MR. J. H. BRINDLE has been appointed Manager, Publicity Department, Air Control Installations Ltd., Victoria Road, Ruislip, Middlesex, as from January 1. Mr. Brindle has been with Air Control Installations for the past 14 years, mainly in technical departments. He has previously had experience of printing and allied trades.

OBITUARY

MR. ARTHUR FORSHAW, who until his retirement in 1952, was chief chemist of R. & A. Main Ltd., died on December 30, aged 76. An honours graduate and M.Sc. of the Victoria University of Manchester, Arthur Forshaw entered the industry as an assistant chemist at the Earl of Ellesmere's Brackley cokeworks in 1905, and from 1907-1909 became the first holder of the Institution Research Fellowship at Leeds University. In 1909 he was appointed chief chemist, John Wright & Co., Ltd., and 1919 chief chemist, Fletcher Russell & Co., Ltd. In 1923 he became chemist to and convenor and secretary of the I.G.E. Committee on Standard Methods of Testing Gas Ovens, on which subject he became a major authority. In 1924 Mr. Forshaw joined R. & A. Main Ltd. as chief chemist, which post he continued to occupy during his 28 years with the firm. He was the author of many pamphlets, that most widely known being 'Improving the Breed'—the story of the origin and development of the gas cooker. An able lecturer and witty speaker, he was for many years a member of Council of the Gas Research Board, and a member of the Engineering Divisional Council of the British Standards Institution.

FORTHCOMING EVENTS

January 7.—EAST MIDLANDS G.C.C.: Smithy Row, Nottingham. Council meeting at 11 a.m.

January 8.—LONDON AND SOUTHERN JUNIORS: 'A Re-organisation of Customer Service,' by D. Foulis.

January 8. — SCOTTISH WESTERN JUNIORS: 9, George Square, Glasgow. 'Heat Service in New Buildings,' by R. D. Bruce.

January 9. — EAST OF SCOTLAND JUNIORS: Dunfermline. Short paper day.

January 12.—MIDLAND JUNIORS: Paper by Mr. J. D. Cormack, Birmingham, on 'The Design and Operation of an Axial Flow Gas Compressor Station.'

January 13.—SOUTH WESTERN SECTION, I.G.E.: Bridgwater. 'The Preparation, Distribution and Use of Petroleum Products in the Gas Industry,' by G. F. J. Murray. Preceded by visit to the new p.f.d. equipment on the vertical retort installation at Bridgwater manufacturing station, and the new distribution depot of Shell-Mex & B.P. Ltd., at Dunball, near Bridgwater.

January 14.—INSTITUTION OF PLANT ENGINEERS, GLASGOW BRANCH: Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow. 'Selection of Heating Systems for Factories and Offices,' by T. Turner. Joint meeting with the Institution of Heating and Ventilating Engineers. 7.15 p.m.

January 15.—COKE OVEN MANAGERS' ASSOCIATION, SOUTHERN SECTION: Park Hotel, Park Place, Cardiff. 'Basic Work on Coal Carbonisation,' by Dr. I. G. C. Dryden.

January 15.—WALES G.C.C.: Bute Terrace, Cardiff. Council meeting.

January 16. — YORKSHIRE JUNIORS: Wakefield. Short paper day.

January 19.—LONDON AND SOUTHERN JUNIORS: Visit to Elliott Brothers (London) Ltd., at Lewisham.

January 19.—LONDON AND SOUTHERN SECTION, I.G.E.: Pepys House, 14, Rochester Row, London, S.W.1. 'The Application of Electronics in the Gas Industry,' by M. Needham and J. H. Whitaker.

Calendar and Directory

We regret that copies of the 'GAS JOURNAL' Calendar and Directory are not yet available owing to delays caused by the printing dispute last year. It is hoped to mail copies by the end of this month.

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APPOINTMENTS VACANT

PALMERSTON NORTH CITY COUNCIL

NEW ZEALAND

APPLICATIONS are invited for the position of Gas Manager and Engineer to the above Undertaking. Full particulars may be obtained from the London Agents to the Council, Messrs. Wm. Coward & Co. Ltd., 3, St. James's Square, London, S.W.1.

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WEST MIDLANDS GAS BOARD

WARWICKSHIRE DIVISION

VACANCY FOR
ASSISTANT CHEMIST, COVENTRY DISTRICT

APPLICATIONS are invited for the above post, which is located at Foleshill Works, Coventry.
Candidates must possess the Higher National Certificate and have had some years' experience in the chemical control of Gas Works Plant.
The salary for the appointment, which is pensionable and subject to medical examination, will be within the range of £733-£813 per annum.
Applications, stating age, experience and qualifications, together with the names of two referees, should be addressed to Mr. A. Allen, Divisional General Manager, West Midlands Gas Board, Gas Street, Coventry, **to reach him not later than January 14, 1960.**

EAST MIDLANDS GAS BOARD

LEICESTER AND NORTHANTS. DIVISION

INDUSTRIAL GAS

APPLICATIONS are invited for the following appointments in the Sales and Service Section of the Divisional Office, Leicester.
Vacancies are created by reorganisation of the Section and afford excellent opportunities for suitably qualified persons.

Divisional Industrial Gas Engineer
The Divisional Industrial Gas Engineer will be responsible for the organisation, development and maintenance of industrial gas sales throughout the Division; and will directly supervise and control all associated personnel within the Leicester Group.
Applicants should hold a recognised qualification, such as a degree in Engineering or Fuel Technology, and should have considerable practical experience in a suitable field of industry. The commencing salary will be within the range £1,155-£1,355

Industrial Gas Engineers, Leicester
These posts, under the control of the Divisional Industrial Gas Engineer, are suitable for candidates possessing qualifications appropriate to Associate Membership of the Institutions of Mechanical Engineers, Gas Engineers, Heating and Ventilating Engineers or the Institute of Fuel.
They will be required to advise, survey and quote for the installation of suitable industrial gas equipment within the Leicester Group and to arrange for its subsequent installation and maintenance. The commencing salary will be within Grades APT. 9/10 (£827-£1,002) of the National Salary Scales.
The posts are pensionable and the successful applicants will be required to pass a medical examination.
Applications stating age and giving full details of education, qualifications and experience together with the names of two referees should be addressed to the Secretary, East Midlands Gas Board, Beverley House, University Road, Leicester, to reach him not later than January 31, 1960.

EAST MIDLANDS GAS BOARD

NOTTS. & DERBY DIVISION

ASSISTANT DISTRIBUTION ENGINEER—MANSFIELD DISTRICT

APPLICATIONS are invited from suitably qualified persons for the above position at a salary within Grade A.P.T. 9/10 (£827/£1,002).
Applicants should possess the Higher Grade Certificate (Supply) of the Institution of Gas Engineers or an equivalent qualification and should be experienced in all branches of gas distribution at both low and high pressures.
The position is pensionable and the successful applicant may be required to pass a medical examination.
Applications stating age and experience, giving full particulars of training and qualifications, together with the names of two referees, should be submitted to the undersigned not later than fourteen days after publication of this advertisement.

K. L. PEARCE,
Divisional General Manager.

East Midlands Gas Board,
Notts. and Derby Division.
P.O. Box No. 62,
Friar Gate,
Derby.

THE UNIVERSITY OF LEEDS

THE JOINT RESEARCH COMMITTEE OF THE GAS COUNCIL AND THE UNIVERSITY OF LEEDS

APPLICATIONS are invited for research staff to work on an intensive research programme on the chemical, biological and chemical engineering aspects of trade effluent disposal. Applicants should have a degree or equivalent scientific qualification and experience would be an advantage but is not essential. Salaries will be within the range £620-£980, but higher salaries will be considered for specially qualified candidates. Applications (three copies) stating date of birth, qualifications and experience, should reach The Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than January 31, 1960.

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